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Transactions on Maritime Science (ToMS) is a scientific journal with international peer review which publishes papers in the following areas:

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The journal is published in English both as an open access journal, and as a classic paper journal (in limited editions).

ToMS aims at presenting major maritime research all over the world, particularly focusing on the Mediterranean area. Articles will be double-blind reviewed by three reviewers. ToMS also promotes scientific collaboration with talented students at a beginning of their scientific careers. These papers also undergo strict peer reviews. Furthermore, the Journal publishes short reviews on significant papers, book reviews and workshops in the fields of maritime science.

The views and opinions expressed in the papers are those of individual authors, and not necessarily those of the ToMS editors. Therefore, each author will take responsibility for his or her contribution as presented in the paper.

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From Editor-in-Chief

Igor Vujović

The Editorial Board of Transactions on Maritime Science hope that the journal will contribute to the scientific recognition of our publisher, the Faculty of Maritime Studies, University of Split. This issue continues with the practice of international double-blind peer review. We would like to take this opportunity to congratulate our publisher on its 60th anniversary. Our Dean, Pero Vidan, a former Senior Editor of the journal, and Ivica Kuzmanić, the journal's former Editor-in-Chief, are the editors of the Faculty's monography, to be published in December 2019 to mark the institution's 60th anniversary. As always, the journal is available in printed and electronic, open-access form.

There have been some changes since the previous issue. The number of Advisory Board members increased to include new members from Australia, Germany, Sweden and the USA. Since we already had regional editors on three continents, the journal is now present on all continents, which additionally contributed to its internationalization.

In order to enable our authors to disseminate their research between issues, ToMS implemented "web-first".

This issue presents researches from Bosnia and Hercegovina, Croatia, India, Malaysia, Poland, South Africa, and Spain – three continents. The papers deal with topics from a variety of scientific areas and fields: marine engineering, naval technology, autonomous ships, hydrographic forensics, with special focus on port management.

Staying true to our mission to preserve Croatian cultural heritage, this issue of ToMS brings you two poems by Ante Božanić Pepe, written in the idiom of the Island of Vis. The contribution comes in bilingual form, in the inspired translation of Mirna Čudić Žgela, our long-standing collaborator. As a special bonus for the readers of the electronic edition, ToMS made available audio recordings of the poems in the striking rendition of the author.

ToMS encourages contributions in the fields of ocean engineering, marine engineering, and marine electrical engineering.

As always, we hope that the papers we publish will encourage your cooperation.

Please note that the journal is not liable for the contents of papers and contributions. Rather, it is the author's obligation to obtain all permissions requisite for publication.

Finally, I would like to thank our reviewers on their assistance with the selection of papers and the improvement of their content. I likewise thank the authors who were willing to listen to the reviewer's advice to make their papers better.

A Procedure for Implementing Exploratory Mixed Methods Research into Dry Port Management

Jagan Jeevan[a], Yapa Mahinda Bandara[b], Nurul Haqimin Mohd Salleh[a], Abdulhafaz Ngah[c], Rudiah Hanafiah[a]

Qualitative approach has become the main method of exploring significant dimensions in dry port research. Quantitative approach has also been employed to examine empirical evidence in this research area. The application of mixed methods has been proposed in the dry port research to provide a multidimensional insight into seaport research issues. This paper provides guidance on mixed method application in dry port research and demonstrates that the implementation of mixed methods research is capable of providing comprehensive results by integrating qualitative and quantitative results in a single research. The availability of different dimensions and alternative designs lends this approach wide applicability, facilitating the production of valid and reliable outcomes and ensuring high level of generalizability of dry port research.

KEY WORDS

~ Dry ports
~ Mixed methods
~ Grounded theory
~ Exploratory factor analysis
~ Malaysia

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1. INTRODUCTION

Research methods in maritime logistics and management are crucial for assisting researchers in the examination of interesting themes and topics in this particular area. In general, quantitative research has become more popular than qualitative research (Shi & Li, 2017) because qualitative methods, which include surveys, interviews, questionnaires, observations (SIQO), conceptual, content, comparative and qualitative analysis (CCCQ) can not provide precise or practicable conclusions in a scientific manner. On the other hand, quantitative methods offer an advanced analytical technique for a comprehensive research outcome. Shi and Li (2017) have conducted thorough research on the types of methods applied in 1292 journal papers published between 2000 and 2014, which has shown that quantitative methods had been used in 951 papers, compared to 341 papers whose authors opted for the qualitative method. This trend shows that the application of quantitative methods has dominated maritime logistics and management research. However, some qualitative research is required, especially when following a new line of research in maritime logistics and management.

In addition, the issue of generalisability and transferability of quantitative and qualitative research has become an important contributing factor to the dominance of quantitative over qualitative research in maritime logistics and management. Castro and Nieri (2008) agree that the explanatory power of mixed methods in maritime research exceeds that of either the quantitative or qualitative approach used on their own. Hence, in this paper, the application, advantages and challenges of mixed

methods will be explored in connection with research on dry ports. This paper is organised as follows: Section 2 provides an overview of research methods and their application in dry port research. Section 3 describes the application of mixed methods in Malaysian dry port research, consisting of qualitative and quantitative phases. Section 4 elaborates the strategy of mixing qualitative and quantitative results. The findings are recapitulated and discussed in Section 5.

2. APPLICATION OF RESEARCH METHODS IN DRY PORT RESEARCH

Recently, the integration of quantitative and qualitative methods has become the methodological trend in dry port research. The trend became highly noticeable in 2009-2018 in journal papers gathered from reliable sources, especially from prominent journals on maritime logistics and management. Those journals include Transport Policy, Maritime Economics & Logistics, Research in Transportation Economics, Maritime Policy & Management, Research in Transportation Business & Management, Regional Studies, Journal of Transport Geography, Transportation Research Part C: Emerging Technologies, Journal of Coastal Research, The Asian Journal of Shipping and Logistics and Journal of International Logistics and Trade. Nevertheless, qualitative methods are used far more frequently in dry port research than quantitative methods. For example, some of the authors including Ng and Gujar, (2009); Garnwa et al. (2009); Roso and Lumsden, (2010); Cullinane and Wilmsmeier, (2011); Hanaoka and Regmi, (2011); Haralambides and Gujar, (2011); Do et al. (2011); Rodrigue and Notteboom, (2012); Beresford et al. (2012); Ng et al. (2012); Monios and Wilmsmeier, (2012); Padilha and Ng, (2012); Ng et al. (2013); Bask et al. (2014); Jeevan (2015); Li et al. (2015) and Nguyen and Notteboom, (2016) have employed qualitative approach in dry port research (see Table 1).

On the other hand, the use of quantitative method in dry port research is lagging behind the qualitative method. Owing to limited literature on dry port research, an emerging prospect in seaport systems, as well as to the dynamic environment of the maritime sector, there is little opportunity to use the quantitative method in this specific area, giving more room to qualitative research. Mixed methods research combines the elements of both qualitative and quantitative research approaches during data collection, analysis and inference for the broad purposes of breadth and depth of understanding and corroboration (Johnson et al., 2007, p. 123). Effectiveness is the main reason for the application of mixed methods research, since its output exceeds that of mono method studies (Onwuegbuzie & Leech, 2004). The combination of insights and procedures from two different paradigms provides a more productive and effective solution resulting in a superior product (Johnson & Onwuegbuzie, 2004). It offers separate interpretations of identifiable qualitative and quantitative data, providing a more coherent and comprehensive output than either mono method (Tashakkori & Creswell, 2007).

3. MIXED METHODS RESEARCH IN MALAYSIAN DRY PORTS

Mixed methods design consists of 4 main designs, namely: triangulation, embedded, explanatory and exploratory designs (Creswell & Clark, 2007). Triangulation design concurrently collects qualitative and quantitative data, merges both sets of data and uses the outcome to address a research problem (Jick, 1979). Embedded design simultaneously collects qualitative and quantitative data, with one form of data supporting the other (Tashakkori & Teddlie, 2003). In explanatory design, quantitative data are collected first, following which qualitative data are used to explain and elaborate quantitative results in detail (Creswell & Clark, 2007). Exploratory design starts from qualitative data and then collects quantitative information. The aim of this design is to gather qualitative data to explore the phenomenon and follow up by using quantitative data to explain the relationships between the previous data (Creswell, 2008).

In this paper, the application of exploratory design in Malaysian dry port research is elaborated. The research questions include: RQ1(*What are the roles and challenges of existing Malaysian dry ports in the container seaport system?*) and RQ2 (*What are the strategies for enhancing Malaysian dry port operations and further development?*). These two research questions are answered in the qualitative phase. Then, an additional research question: RQ3 (*Which influencing factors of Malaysian dry port operations are vital for container seaport competitiveness?*) is answered in the quantitative phase. These three subsidiary research questions have been developed to answer the primary research question exploring the PRQ (*In what way does dry port development in Malaysia contribute to the competitiveness of container seaports in the container seaport system?*). The application of mixed methods does not imply that two types of data sets are literally mixed. The mixing strategy in mixed methods needs to be used from the beginning of research. Hence, all research questions have been answered in the qualitative phase and one validated in the quantitative phase.

The qualitative approach overcomes limitations described in literature dealing with the role, challenges and strategy of dry port development in container seaport systems. The quantitative approach validates results obtained using the qualitative method and analyses the influencing factors of Malaysian dry port operations to determine the impact of dry ports on seaport competitiveness. Qualitative method gives us a better understanding of the inner experience of participants, explores areas not yet thoroughly researched, discovers relevant variables that can be used in the quantitative method and offers a comprehensive approach to studying the phenomena.

This research has a combination of exploratory and explanatory purposes, taking both inductive and deductive approaches. First, it is exploratory-based, due to being a limited study aiming to determine the role of Malaysian dry ports and the challenges they face in the seaport system. Limited research has been conducted to identify and address strategies to overcome these challenges in dry port operations. An inductive approach is suitable for exploring this issue using the qualitative approach, which falls under the philosophy of constructivism. Second, the deductive approach is required to address the important factors influencing dry port operations in the container seaport system. Explanatory research is required because it establishes the correlation between dry ports and the competitiveness of container seaports. The correlation between dry port and container seaport competitiveness is addressed in the quantitative phase which falls under the philosophy of post-positivism (see Table 2).

Table 1.
Application of research methods in dry port research.

Author	Research methods
Ng, A.Y. and Gujar, G.C., 2009.	In-depth interviews
Garnwa, P., Beresford, A. and Pettit, S., 2009.	SWOT Analysis
Roso, V. and Lumsden, K., 2010.	Extensive literature review & in-depth interview
Wei, J., Sun, A. and Zhuang, J., 2010.	A Fuzzy Analytical Network Process (FANP)
Cullinane, K. and Wilmsmeier, G., 2011.	Application of Port Life Cycle
Henttu, V. and Hilmola, O.P., 2011.	Macro gravitational models of distribution
Hanaoka, S. and Regmi, M.B., 2011.	Case study
Haralambides, H. and Gujar, G., 2011.	In-depth interviews
Do, N.H., Nam, K.C. and Le, Q.L.N., 2011.	Case study
Veenstra, A., Zuidwijk, R. and Van Asperen, E., 2012.	Simulation
Rodrigue, J.P., and Notteboom, T., 2012.	Case study
Beresford, A., Pettit, S., Xu, Q. and Williams, S., 2012.	In-depth interviews
Ng, A.K. and Cetin, I.B., 2012.	Case study
Monios, J. and Wilmsmeier, G., 2012.	Literature review
Padilha, F. and Ng, A.K., 2012.	In-depth interviews
A. K.Y. Ng, F. Padilha, and A.A. Pallis,2013	In-depth interviews
Bask, A., Roso, V., Andersson, D. and Hämäläinen, E., 2014.	Case study
Ambrosino, D. and Sciomachen, A., 2014	Mathematical programming model
Crainic, T.G., Dell'Olmo, P., Ricciardi, N. and Sgalambro, A., 2015.	Mathematical programming model
Jeevan et al., 2015	In-depth interviews
Li, Y., Dong, Q. and Sun, S., 2015.	Case study
Nguyen, L.C. and Notteboom, T., 2016.	Case study & SWOT analysis
Jeevan et al., 2018a.	Regression analysis
Jeevan et al., 2018b.	Exploratory Factor Analysis

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Table 2.
Inductive and deductive phase.

Stages	Research approach	
Phase & approach	Phase 1- Inductive	Phase 2- Deductive
Input	Interview with dry port operators, seaport authority and operators, and government bodies.	Compilation of online questionnaire and its distribution to dry port stakeholders.
Process	Grounded theory to identify the main theme of each section.	Exploratory factor analysis for data validation.
Output	In-depth insight into the role of dry ports and the challenges faced in the container seaport system. Identification of factors influencing dry port operations. Platform established for Phase 2 research.	Validation of factors influencing dry port operations. Determining the correlation between dry port and seaport competitiveness.

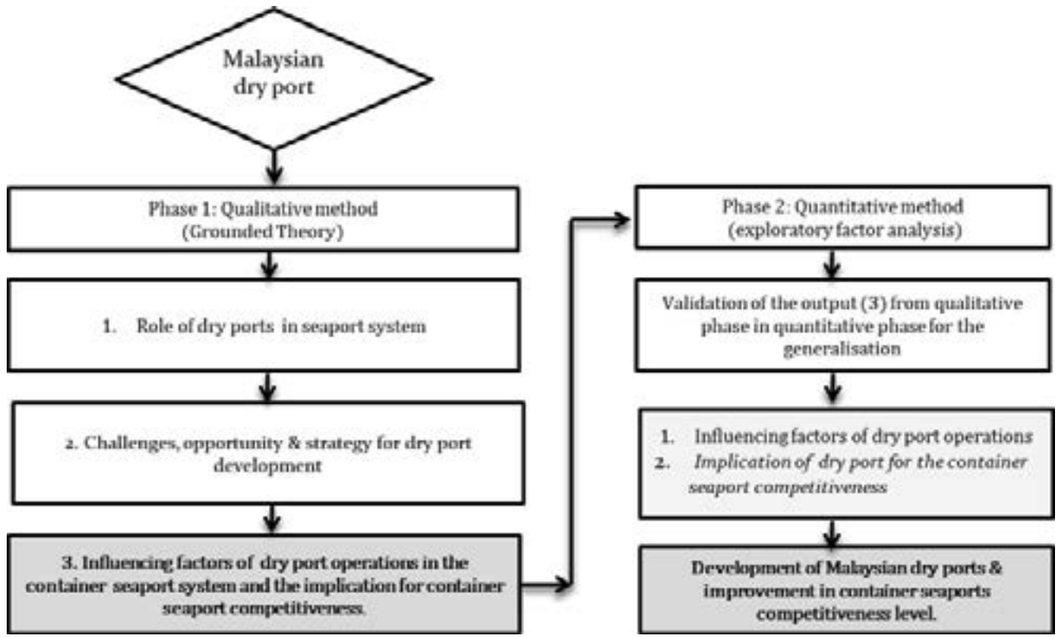

Figure 1.
Questionnaire mixing in mixed methods (Source: Authors).

A combination of qualitative and quantitate approaches has been incorporated into this paper using exploratory mixed methods design. A pragmatic dimension is required to rationalise and generalise the outcome from a broader point of view. Moreover, conducting research using the mixed method prevents the occurrence of some potential issues that might plague mono-method research, such as small sample size, limitations with respect to database validation and difficulty fully understanding the research problem (Bryman et al., 2008).

Alternatively, there are two different stages involved, beginning with the qualitative phase and followed by the quantitative phase. The first phase involves qualitative data obtained from a small number of individuals, followed by a survey conducted on a large and selected population. The purpose of quantitative data in this design is to refine and expand initial findings in order to obtain detailed and generally applicable results. The advantage of this design is that it allows the researcher to identify measures based on data collected from respondents. Face-to-face interviews are a better method of learning participants' views than approaching the respondents with a predetermined set of variables (Creswell, 2008). Creswell adds that this design can be tested by considering the length of time required for its execution. After pretesting, the researchers must decide which themes to measure in the quantitative data collection stage.

During the compilation of questionnaires for both phases, special attention was paid to carefully formulate questions so as to ensure application of the mixed strategy from the beginning of the research. Three main questions have been formulated in the qualitative phase to identify the role, challenges, opportunities and strategies for dry port development. Then, in this same phase, the question which influencing factors of dry port operations are vital for seaport competitiveness was also raised. In the second phase, the answers obtained in the qualitative phase have been validated by asking two main questions, i.e. what is the influencing factor of dry port operations and what impact do dry ports have on seaport competitiveness as indicated in Figure 1.

3.1. Qualitative Phase

In the qualitative phase, information about the role of Malaysian dry ports was collected. This information needs to be collected from a number of experienced individuals participating in the process (Morse & Mitcham, 2002). Therefore, in this research, experienced respondents from various organisations were selected to share their experience with dry port development in Malaysia. The respondents came from the ranks of Malaysian dry port operators, Malaysian seaport authorities, seaport operators and governmental bodies. Each of these groups provided its own perspective on the role of dry ports and the challenges they face. In this stage, a convenient sampling design was adopted to choose eligible and potential participants of the face-to-face interview. A total of 14 participants from middle and top-level management were selected because this group has the authority to decide to optimise resources and propose a new development strategy (DuBrin, 2003) on behalf of their organisations. The

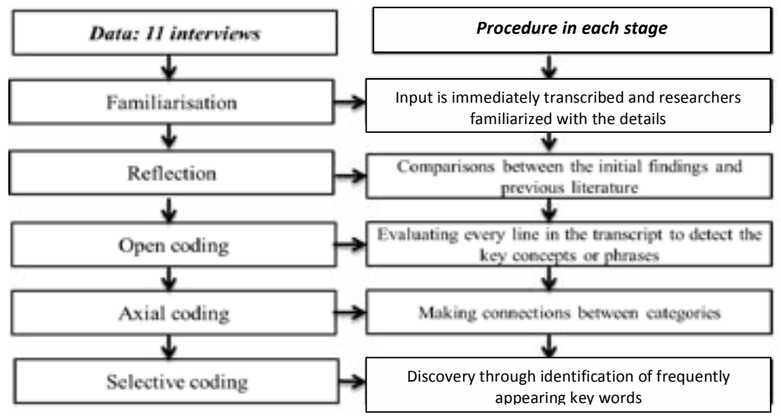

Figure 2.
Key processes in Grounded Theory (Source: Adapted from Creswell (2013)).

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results of this phase have been analysed using grounded theory to answer the research question, with the additional output being the transition to the second phase.

Grounded theory was applied in the first phase of the research because it is the best approach to examining dry port operations in the Malaysian container seaport system. The limited amount of research suggests that the issue of dry ports has not been addressed in-depth, and provides only vague information on the emergence of dry ports in the container seaport system in Malaysia. In this respect, the research used grounded theory to arrive at clear conclusions on how dry port operators, seaports, policy makers and transport operators feel, think, and behave in the context relative to the two proposed secondary research questions. The grounded theory approach pursues generalisations by making comparisons across the social situation and has the capacity to encompass many different data and analytical perspectives with real-world problem solving (Corbin & Strauss, 2008). This advantage, crucial for the research, ensures the integration of data from various stakeholders, including dry port operators, to provide a systematic approach to proposed secondary research questions.

During data analysis using grounded theory, five steps were followed to identify significant themes for each interview question (see Figure 2). First, familiarisation was used to immediately transcribe inputs and familiarise the researchers with the details. In the reflection stage, initial findings were compared with previous literature. Open coding and axial coding are the following steps. They involve the evaluation of transcript content to identify key concepts and establish how they are connected. Finally, selective coding, as the last procedure in grounded theory, aims to examine new findings by identifying frequent appearance of key words. During this stage, themes for SRQ1, 2 and 3 have been developed.

3.2. Qualitative Data Analysis

Questions asked in the interview sessions were divided into three main sections. The first section concerned the role of dry ports in the Malaysian seaport system. There were six questions in this section: the definition of dry ports, objectives and functions of dry ports, the clients of dry ports, inquiries into dry ports' operation and the benefits of the assistance of dry ports in managing cargoes transported to and from seaports. The second section examined the challenges faced by dry ports in the seaport system. The interview questions in the final section concerned the influencing operating factors of dry ports and consist of two main parts. The first part is about important factors contributing to the development of dry ports and seaport competitiveness.

According to Suddaby (2006), grounded theory is an interpretative process involving the researcher and the data. The usage of the qualitative software for data interpretation is not advisable because that software is incapable of detecting theoretical sensitivity, which is crucial in an interview session. Theoretical sensitivity is the ability to derive concepts from data to develop a theory. Theoretical sensitivity facilitates the formation of assumptions and knowledge structure from description to theoretical analysis (Parker & Roffey, 1997). Theoretical sensitivity develops from professional experience, personal experience, knowledge and skills (Strauss & Corbin, 1998).

3.3. Bias Management Procedures for the Qualitative Phase

Bias management throughout the research ensures the quality of the research. Typically, bias occurs during presentation and report writing (Creswell, 2013). During the qualitative phase data collection, the most important technique of bias minimisation is the establishment of rapport and trust with the respondents (Zikmund et al., 2010). Therefore, in this research, the respondents were contacted by telephone and email, which allowed the researchers to understand their social context before holding the interview. Apart from rapport establishment, several other, subsequent strategies have been implemented in the qualitative phase. The first is being ethical, especially during data analysis and the presentation of findings (Rudestam & Newton, 2001). The researchers must not allow their personal experience, beliefs and judgements to affect the interviews. Moreover, the interview sessions were recorded for reference and final data integration (Creswell, 2013). Second, sensitive and offensive language must be avoided. For example, gender-biased words, suggesting judgements or reinforcing stereotypes are an undesirable category of expression (Rudestam & Newton, 2001). Third, the use of appropriate research terminology and four - interview and survey questions need to be pre-tested (Creswell, 2013). Finally, interview and online survey questionnaires need to be pre-tested to prevent any bias in the data collection procedure.

3.4. Reliability and Validity of Qualitative Results

First, the reliability of the qualitative phase was examined by establishing recording procedures for field notes (Kirk & Miller, 1986). High reliability can be established by preparing four separate field notes, namely: a condensed account which contains the recordings of what happened, expanded account consisting of a log of events drawn up immediately after each interview session, the field work journal of cognitive experiences, such as ideas, emotions, mistakes and concerns noted during the interview session and finally a running record of interpretation drawn up during the interview (Kirk & Miller, 1986).

The second reliability test in this phase was cross-checking. Cross-check coding was incorporated into this phase to improve reliability, since humans are prone to judgement errors (Franklin & Jordan, 1997). Increasing reliability and coming up with new concepts or theories based on existing data sources are of key importance in this phase. During qualitative data analysis, cross-checking using various coding processes was implemented. Open coding, axial coding and selective coding were executed to improve the interpretation of data received from respondents and increase the reliability of output in this phase. Multiple cross-checks against existing literature were performed during coding sessions to devise a solid concept based on new findings.

Data reliability was improved by regularly checking the transcripts to ensure that they do not contain obvious mistakes made during transcription (Creswell, 2013). Transcripts were made after each interview session while the memory of the interview with the respondent was still fresh, to reduce the percentage of transcription mistakes. Once the text was transcribed, the transcript was re-checked several times to ensure data credibility.

To validate the results obtained in the qualitative phase, triangulation or purposeful sampling was implemented during the interview session. The triangulation technique is a cross-case analysis used for testing findings during the interview session (Reason & Rowan, 1981). For example, in this study, dry port operators were asked about, e.g. the type of services provided by Malaysian dry ports, the facilities they currently have and the relationship of Malaysian dry ports with other seaports. After gathering the information from Malaysian dry port operators, dry port stakeholders or clients were asked the same questions. If the answers provided by different organisations to the same question are largely similar, the finding is highly trustworthy (Reason & Rowan, 1981). The triangulation technique is the replication of

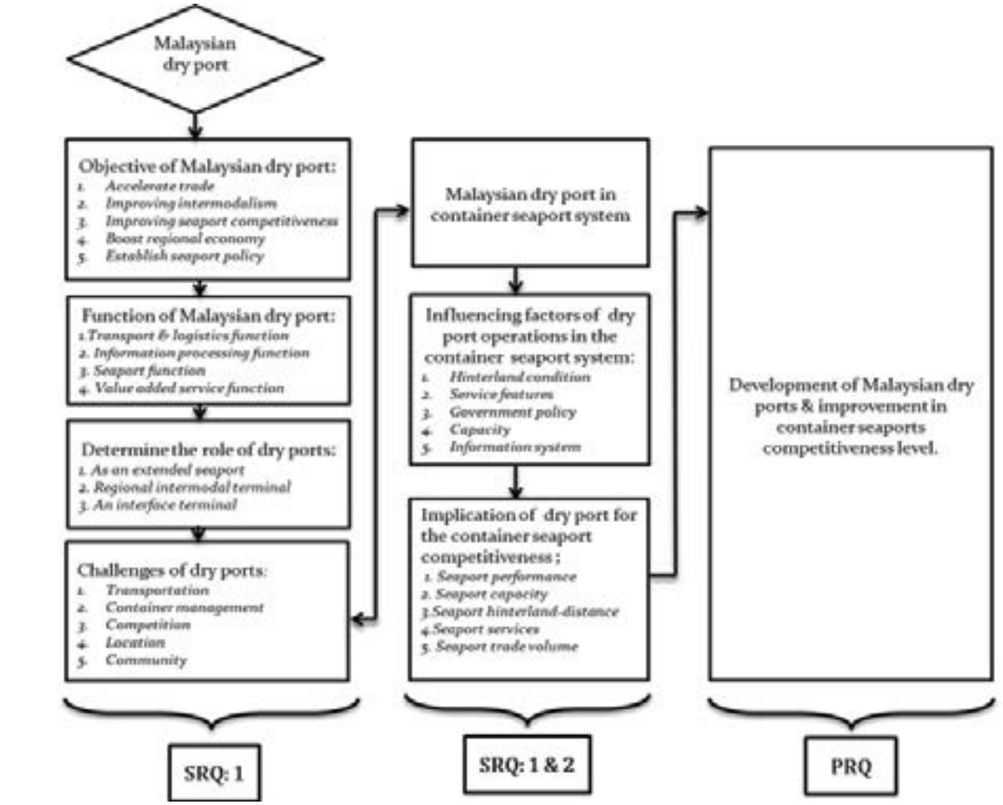

Figure 3.
Themes developed during grounded theory (Source: Authors).

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the finding using data collected from new participants, settings and events (Guba & Lincoln, 1994). In this study, inputs from dry port operators, seaport authorities, seaport operators and governmental bodies were found to be largely similar during cross-case analysis.

Furthermore, reflexivity was used as a sequential test to verify the validity of qualitative data. Reflexivity is the ability to examine oneself (Padgett, 2009). During data gathering, open disclosure of preconceptions and assumptions may affect the output (Padgett, 2009). Thus, neither emotional struggle nor conflicts of interest must influence the researcher during the interview session, which reduces the biasness of results.

To ensure optimum validity of data collected in the qualitative phase, the members' checks technique was applied. At this point, all collected data were sent to participants of the research to obtain feedback. In qualitative research, feedback from participants helps validate the interpretation of the interview (Tutty, 1996). Next, spending prolonged time in the field is one of the methods of determining the validity of collected data, which allows the researcher to develop an in-depth understanding of the phenomenon. The greater the experience with the participants and the phenomenon, the higher the accuracy or validity of the findings (Creswell, 2013). Although allocated interview time is only 30-40 minutes, participants are motivated with additional questions, that prolong the interview to over an hour.

Transcripts were checked regularly to ensure that they did not contain obvious mistakes made during transcription (Creswell, 2013). The transcription was carried out after each interview session to draw on fresh memories of the interview with the respondent, to reduce the percentage of transcription mistakes. In addition, the transcripts were re-checked several times to improve data credibility. Figure 3 indicates the themes developed during grounded theory.

3.5. Quantitative Phase

The objective of the quantitative phase is to validate data on the dry ports' operating factors and their impact on competitiveness of Malaysian seaports. The sample for the quantitative phase was 170 respondents, selected among dry port stakeholders. The respondents came from a variety of groups, such as freight forwarders, shippers, shipping lines and hauliers, rail operators and seaports. They are the key players in dry port operation and have a significant role in dry port operations in the seaport system (Roso & Lumsden, 2010). The results obtained from this group refine and expand qualitative findings (Creswell, 2013). In this stage, online survey was chosen as means of questionnaire distribution. Stratified sampling was used to garner adequate data to analyse multiple subpopulations. It is an effective sampling strategy for studying the characteristics of a particular population, its points of view or standings on certain issues (Creswell, 2008).

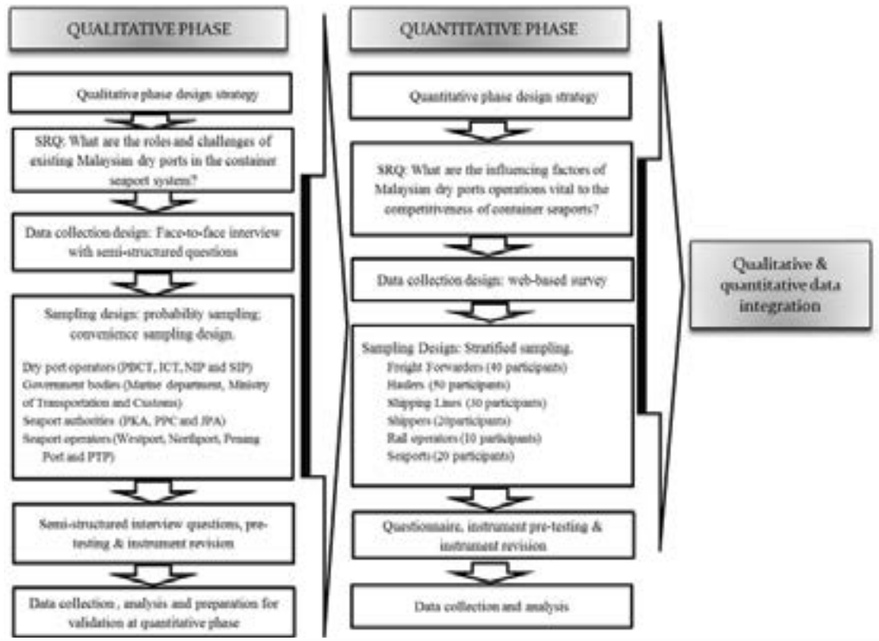

Figure 4.
The flow of mixed methods implementation (Source: Authors).

In the quantitative phase, a mixture of descriptive and inferential statistical analysis was used by exploratory factor analysis (EFA). EFA is exploratory in nature and examines main dimensions to derive a concept, theory or model from a large set of items (Williams et al., 2010). In this research, EFA was used to validate and explore the correlations between the factors that influence Malaysian dry port operations and the impact of dry ports on seaport competitiveness. The objective of the second phase of the research was to evaluate these factors and construct a parsimonious description of the data structure. Both approaches are important for defining newly developing features or dimensions of factors that underline the set of items (Tabachnick & Fidell, 2000). The nature of this research is mixed methods, focusing on exploratory sequential design and an application of EFA to validate the themes emerging from the constant comparison phase (Creswell & Clark, 2007). According to Hurley et al. (1997), the EFA technique is suitable for factor exploration and evaluation compared to confirmatory factor analysis (CFA).

The initial exploration provided detailed and generalised results using the following quantitative analysis. The combination of qualitative and quantitative approach allows an exploration of views by listening to participants and following up with sequential questions to gain additional information on certain phenomena (Tashakkori and Teddlie, 2010). Figure 4 illustrates the research flow of two different methodologies integrated to provide answers to subsidiary research questions (SRQ). Meanwhile, the primary intention of the integration of data obtained in the qualitative and quantitative phases is to answer the primary research question (PRQ).

3.6. Quantitative Data Analysis

Statistical analysis of quantitative results was conducted using Statistical Package for Social Science software (SPSS) version 22.0. Analysis results were displayed in table, chart and graph form. However, the interpretations of the impact of dry port development on container seaport competitiveness have been derived by integrating data from both phases.

3.7. Bias Management Procedures in the Quantitative Phase

The application of EFA requires a bias analysis using Common Method Bias (CMB). Therefore, the common method bias has been conducted through Harman single factor analysis for using EFA, where all 42 variables loaded into a single factor. In any analysis, the newly introduced common latent factor accounts for over 50 percent of the variance indicating the presence of bias in the result (Eichhorn, 2014). However, in this research, the Common Method Variance (CMV) value was 27.015 percent and clearly indicates the absence of bias in the findings (see Table 3).

Table 3.
Outcome of CMV.

Total Variance Explained						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	**% of Variance**	Cumulative %
1	14.048	27.015	27.015	14.048	**27.015**	27.015
2	4.470	8.596	35.611			
3	3.465	6.663	42.274			
4...	2.776	5.338	47.612			

3.8. Reliability and Validity of Quantitative Results

In quantitative analysis, validity is measured to establish whether values obtained from the instruments are sensible, meaningful and whether the conclusions drawn from the sample studied are applicable to the population as a whole (Rudner, 2001). Reliability refers to the accuracy of a measurement procedure (Rudner, 2001). In EFA, several assumptions suggested by Pallant (2011), such as sampling adequacy, correlation coefficient and communality analysis were analysed to ensure

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the validity and generalisability of the output. The outcome from all assumptions shows that the results are valid and appropriate for generalisation. Content validity means that the questions represent all possibilities of questions available. Content validity was ensured by participants and academic professionals in pre-testing, who commented especially on the content of the survey questions, the structure of the survey and the scale (Rudner, 2001).

The stability of the instrument was ensured by survey instrument pre-testing, or in this case the questionnaire. The stability of the instrument yielded almost identical results when the same instrument was repeatedly administered to the same samples at sufficient time intervals (Klassen et al., 2012). The stratification and optimisation of the entire data collection sampling frame enhance the internal consistency of quantitative phase data collection. Survey questions were based on literature and qualitative outcome. Moreover, literature covering studies on dry ports on other continents, such as Europe, Africa, America and some Asian countries was included. Hence, these procedures are a reflection of construct validity, external validity and generalisability of the quantitative phase. The coefficient-alpha is used for testing the reliability of internal consistency. The items scores are continuous variables, i.e. from "Strongly Agree" to "Strongly Disagree"; alpha provides the coefficient for estimating the consistency of values of an instrument. In the coefficient-alpha test, the higher the score, the more reliable the generated scale in the questionnaire (Klassen et al., 2012). The acceptance coefficient value was indicated as 0.7 and above as acceptable (Garver et al., 2008).

4. DATA MIXING OF QUALITATIVE AND QUANTITATIVE RESULTS

The onset of the mixing stage in exploratory sequential design is not after the end of the study. Rather, the mixing stage starts during the development of qualitative and quantitative research questions in the early stage of the study. The combination of qualitative and quantitative research questions in a single study facilitates the inferential process in the interpretation stage (Tashakkori and Teddlie, 2003). The data integration strategy consists of the coherent presentation of data from both phases as shown in Figure 5 (Onwuegbuzie & Teddlie, 2003). In mixed methods research, data integration is crucial for comparison, consolidation, infusion, building and embedding of qualitative phase results into and with quantitative phase results and vice versa to arrive at a new clarification and understanding (Teddlie & Tashakkori, 2006). This process is critical for determining the quality of outcome in mixed methods research, which has been a significant advantage of these methods (Teddlie & Tashakkori, 2003).

In this study, which employs exploratory sequential design, the mixing was made and connections established during the selection of participants for the quantitative follow-up analysis based on qualitative results. An additional connection point is a more detailed examination of phase one results by collecting and analysing the quantitative data in the second phase (Creswell & Clark, 2011). The connection, mixing and inference have been conducted prior to the interpretation stage, meaning

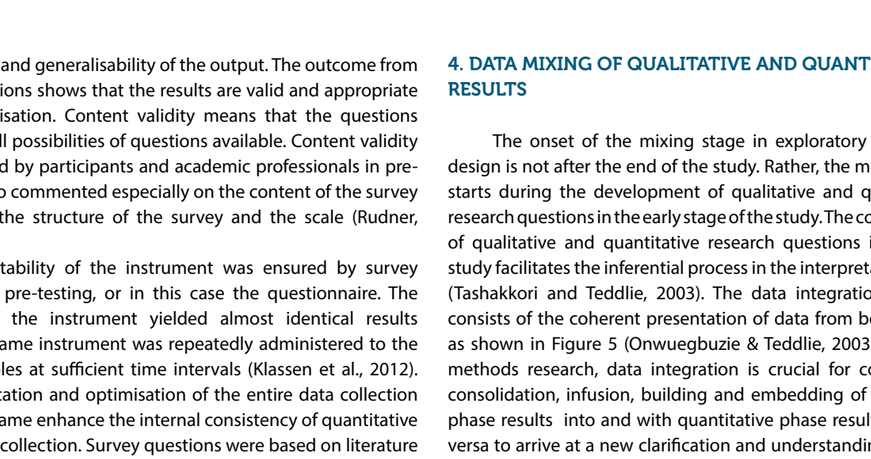

Figure 5.
Data integration in mixed methods research (Source: Authors).

that exploratory mixed methods design was implemented throughout the research process.

The evaluation of mixed methods research does not stop when the two methods are connected, but the study must employ at least one method associated with either qualitative or quantitative research (Creswell & Clark, 2011). In this study, the qualitative method was associated with the quantitative method to gain in-depth explanations and generalise quantitative study results. The evaluation of mixed methods revealed, based on the type of mixed methods employed, that priority was given to qualitative rather than quantitative data, as well as the sequence used in the study (Creswell & Clark, 2011). The validation has shown that exploratory mixed methods were clearly used in the study, although qualitative data collection procedure and analysis were prioritised. Figure 6 shows that the integration of qualitative and quantitative methods commenced at the beginning, rather than at the end of the research.

The fact that mixing started prior to the interpretation stage clearly shows that the exploratory mixed methods design was implemented throughout the research process. The data mixing in this exploratory sequential design did not take place at the end of the study, but rather started during the development of qualitative and quantitative research questions, in the early stage of the study. Secondly, combining qualitative and quantitative research questions in a single study facilitates the mixing process in the interpretation stage. Thirdly, the mixing was conducted during the selection of participants of quantitative follow-up analysis based on qualitative results. Fourthly, the results from phase one have been used as a tool to develop the survey instrument for the collection of data in the quantitative phase.

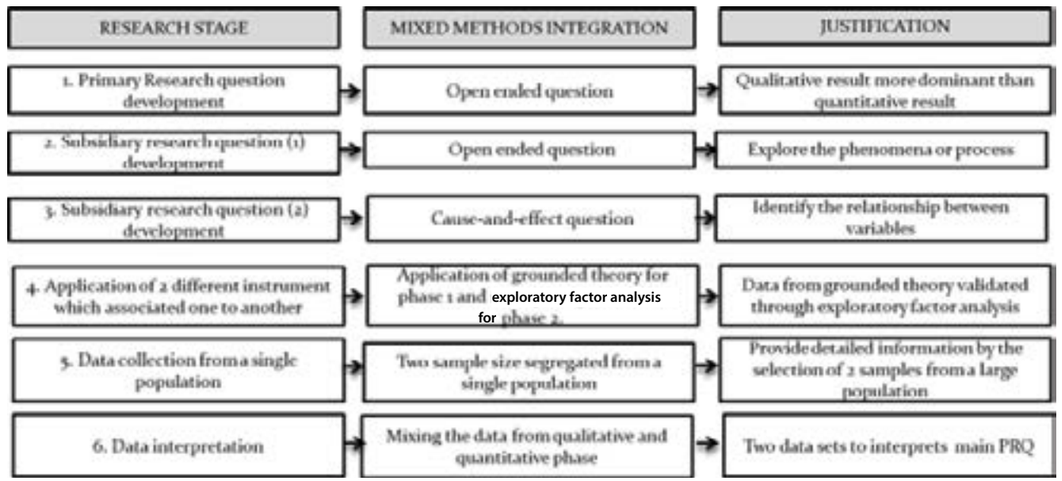

Figure 6.
Evidence of data integration in the beginning of mixed methods research (Source: Authors).

5. DISCUSSION AND CONCLUSION

Dry port studies described in literature mainly adopted the qualitative method, such as Andersson and Roso (2016); Ng et al. (2013); Bergqvist (2013); Roso (2008) and Beresford et al. (2012). This research employed an exploratory sequential design of mixed methods methodology integrating qualitative and quantitative phases in a single research, covering dry ports and seaports. The mixed methods approach has been in use as a research methodology since 1980, especially in the medical science, sociology and education (Creswell & Clark, 2011). By contrast, there is no clear indication of mixed methods application in maritime-related research (Woo et al., 2013). Therefore, this paper sets an example in this regard.

Despite the usage of mixed methods being a growing trend in social sciences, there is insufficient guidance or frameworks for qualitative and quantitative data integration or mixing in many research studies (Bryman, 2007). Although many research studies allegedly integrated qualitative and quantitative findings (Bazeley & Kemp, 2011), the absence of significant data integration examples and the lack of standard examples of qualitative and quantitative data integration restrict

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the utilisation of mixed methods research. Hence, this research contributes by demonstrating a manner of mixing qualitative and quantitative data.

Innovative design should be incorporated in the mixed methods research design process (Creswell & Clark, 2011). The innovation in the design of mixed methods research in this study is that the advantages of both approaches were exploited to address the primary research question in-depth and ensure the generalisability of research results.

Although mixed methods research does have significant benefits, it is more labour intensive, requires extensive resources and its execution takes considerable time. Semi-structured face-to-face interviews were used to obtain more comprehensive and complex data, but the majority of respondents were reluctant to provide particular important and additional data that they considered confidential, which might have opened a wide scope in the research had they been revealed. Moreover, researcher's bias may have been present in the qualitative phase, during data collection and analysis. To overcome this bias, distance from the interviewees was maintained to prevent them being influenced by any beliefs or judgements of the researcher.

Secondly, the use of online survey may have limitations with respect to coverage, dependence on software and uncertainty about the identity of respondents in the survey (Sue & Ritter, 2007). However, these preconceptions are unjustified because online surveys may produce reliable and quality data (Gosling et al., 2004). Limited by time frame, resources and geographical factors, online survey was used due to its flexibility and high accessibility to dry port stakeholders in Peninsular Malaysia.

Thirdly, sampling approaches applied in both phases of the research may have limitations. Since dry ports, seaports and other stakeholders are geographically scattered across peninsular Malaysia, their identification and accessibility were huge challenges in both phases. In the qualitative phase, a convenience sampling strategy was adopted to identify respondents meeting the required criteria and then choosing them on the first-come-first-chosen basis until the sample size was reached. Unfortunately, some respondents who had agreed to participate withdrew at the last minute due to unavoidable reasons. To reduce the risk of missing interviews with information-rich respondents, interview sessions were held in their own preferred venue and time. The interview sessions were continued until data reached the saturation stage, and similar answers to related topics were obtained.

A list-based stratified sampling strategy was used in the second phase. The ability to control the sampling was an important factor, since low internet speed, multiple responses and false identities could have an impact on the quality of the research outcome. Therefore, a list-based stratified sampling developed to control the situation. The goal of this type of sampling is to increase the number of potential participants of this phase. Sampling control at this stage became important due to the difficulty locating appropriate samples, since the goal of the research involved two major specifications - dry port development and container seaports competitiveness. Since the respondents who participated in this phase were stakeholders who keenly used dry ports, they had to be closely inspected before becoming our respondents. Moreover, this sampling strategy was also intended to increase the number of respondents in order for the results to be applicable to the wider population (Wilkinson & Thornton, 1999).

Limited number of professional personnel capable of giving strategic insights into dry ports limited the number of respondents in the quantitative phase. Therefore, generalisability was ensured by developing a competent quantitative phase survey instrument based on the results of face-to-face interviews and relevant literature on dry port operations and container seaport competitiveness. The combination of these steps helped increase the study's scope and generalisability, because the mixed methods strategy contributed to the reliability and validity of the outcome, as the strengths of one phase countered the weaknesses of the other.

A dry port is still a new and emerging area in maritime logistics. Hence, the application of mixed methods research is suitable for the examination and validation of research results, especially in dry port research. Although the qualitative method was used in most of the literature, mixed methods can provide significant outcomes and are suitable for generalisation. Hence, mixed methods are suitable for studying an emerging issue in any area and then producing a concrete justification based on empirical evidence.

The main problem with mixed methods is data mixing. The mixing stage needs to start at the beginning, especially during PRQ and SRQ development, continue to be applied during the application of two different, mutually connected instruments, as well as during data collection from a single population and during data interpretation. This will ensure the relevance and generalizability of data obtained by mixed methods research.

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Automatic Taxiing Direction Control System for Carrier-Based Aircraft

Mariusz Krawczyk, Cezary Szczepański, Albert Zajdel

This paper solves the problem of automatic taxiing direction control of carrier-based aircraft. On modern aircraft carriers, taxiing aircraft either propel themselves using their own engines or are towed by specialised tugs, which requires dedicated personnel and assets. The automatization of this process would simultaneously increase aircraft flow and decrease the number of personnel and assets required. The key challenge in the automatization of this type of process is the development of an automatic control system capable of performing the requisite tasks, which our researchers managed to do. First, the specific conditions of taxiing on-board carriers were analysed and modelled. The model of a fixed-wing aircraft best suited to this purpose was identified and the proper method of automatic control – ADRC – chosen. The algorithm used in the method to facilitate effective direction control of a taxiing aircraft was formulated and extensively tested. The results of automatic taxiing simulation for F/A-18 aircraft have been presented. The conclusion is that the ADRC type control algorithm can ensure effective automatic control of taxiing aircraft.

KEY WORDS
~ Automatic taxiing control
~ Automatic flight control
~ Aircraft taxiing

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1. INTRODUCTION

Taxiing is the movement of an aircraft on the ground before initiating the take off procedure, i.e. preceding the take off run, and after the landing manoeuvre, i.e. after the speed drops below the limit defined as the end of a landing run. The term is most frequently used to describe motion on the ground, or water in case of hydroplanes, and hovering over the runway in case of helicopters equipped with landing skids. Motion along the deck of an aircraft carrier (CVN - aircraft carrier (nuclear propulsion)) or a smaller assault ship (LHD - landing helicopter deck) suitable for fixed wing short take-off and vertical landing (STOVL) aircraft is a special case of taxiing (USA DoD, 2019) due to three reasons. Firstly: taxiing along the deck of an aircraft carrier, or of another sea vessel involves dynamic interaction. Secondly: the ship's speed and weather conditions at sea, characterised by frequent winds of considerable speed, have a direct impact on aerodynamic forces and torques affecting the object (Yangang et al., 2013). Thirdly: the limited surface of a navy ship's deck (in comparison with even the smallest dry land airports) aggravates the take off/landing process, making it more complex and requiring the flawless cooperation of numerous specialized teams divided into seven functional groups.

The basic layout of an aircraft carrier is presented in Figure 1. The recognized definition of taxiing suggests that this process commences once an aircraft is brought to the deck by an elevator. The aircraft is then manoeuvred either to a parking place, or directly to start place containing one of the four steam or electromagnetic (Nimitz/Ford class carriers) catapults. After landing assisted by the Arresting Gear Pendants system, the aircraft either taxis to one of the four available elevators or to a parking place, to be prepped for the next flight.

Considering the conditions characteristic of taxiing on the deck of a navy ship, the challenges of optimisation of this stage of flight may be concluded to be similar to those faced by airport-based aircraft, namely:

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Figure 1.
Nimitz class aircraft carrier (Pixabay).

- the decreasing capacity of airports due to increasing air traffic;
- the need to open civil airspace to unmanned aircraft operations, especially military in character, limiting access to airports;
- problems with the identification of and staying on the right taxiway in case of restricted visibility, especially in oversized airports;
- an increased probability of accidents during taxiing in restricted visibility conditions;
- excessive pilot workload in case of intensive traffic in the airport;
- the two pilot cockpit crew requirement due to the complex handling of some types of aircraft.

Automatic taxiing control systems, having the potential to change the current status quo in the engineering domain, are a relatively new type of aircraft control systems. Until now, they have not gone beyond the concept, project and simulation stages, where the issues of control algorithms, control rules and modelling of taxiing aircraft motion still plague some areas of development.

An aircraft is far from being the "optimal" vehicle for taxiing. While aerodynamic drag minimization is a goal shared by aircraft and car designers, when it comes to lifting force, their goals are quite opposite. Racing car (e.g. Formula One car) designers focus on achieving maximum aerodynamic downforce on a vehicle moving on a racetrack. On the other hand, aircraft designers strive to get maximum lifting force, affecting required runway length. In case of a crosswind, the yawing moment and crosswind force may achieve considerable values, especially in aircraft having a broad side projection and/or a large vertical stabiliser. However, it is the forces and torques generated in the tyre ground contact zone that have the greatest impact on an aircraft's motion. Therefore, the modelling of taxiing aircraft motion has to be a combination of classical aircraft modelling and wheeled vehicle modelling.

2. CONTROL OBJECT MODEL

The McDonnell Douglas F/A-18 Hornet, presented in Figure 2, is a twin-engine, supersonic, all-weather, carrier-capable, multirole combat jet with a three-point landing gear with a front swivel wheel. The main wheels are equipped with disc brakes. The maximum take-off weight is $m=16769\ kg$, wingspan is $l=12,3\ m$, their lift area is $S=18,2\ m^2$ and the mean aerodynamic chord is $c_a=2,91\ m$.

The $O_0 x_g y_g z_g$ coordinate system fixed to the moving carrier is non-inertial due to the two main factors: carrier rotation and lateral linear acceleration, resulting from the high turning rate at high advance velocity, which can reach 30 knots in a Nimitz class carrier. It can be easily demonstrated using only basic calculations that during the turning manoeuvre, total lateral acceleration, resulting from inertial force and the component of gravity associated with the roll angle, is approximately equal to acceleration due to change of direction by an aircraft taxiing at the speed of *5 m/s*. However, in most cases, especially before take-off and after landing, the carrier maintains both course and constant advance velocity. Any unavoidable angular movements may be assumed not to exceed 1°. Moreover, since the mass of the carrier far exceeds the mass of the aircraft, the influence of the aircraft on the carrier is negligible, which is why the carrier-fixed coordinate system $O_0 x_g y_g z_g$ has been treated as inertial for mathematical modelling purposes.

Figure 2.
McDonnell Douglas F/A-18 Hornet aircraft (Pixabay).

Considering the low contribution of control systems and undercarriage to total aircraft weight, the following assumptions have been made in the mathematical modelling of F/A-18 taxiing: an aircraft is a rigid body, has the geometric and mass symmetry plane *Oxz* of the aircraft coordinate system *Oxyz*, originating in the center of aircraft mass. The Newton-Euler formula has been adopted for the formulation of F/A-18 aircraft motion dynamics equations. The following equations have been developed:

$$\begin{aligned} mV + m\Omega V &= F \\ J\Omega + \Omega J\Omega &= M \end{aligned} \tag{1}$$

where: m - constant aircraft mass, $\boldsymbol{F}=[X\ Y\ Z]^T$ - force and $\boldsymbol{M}=[L\ M\ N]^T$ - moment acting on aircraft, $\boldsymbol{\Omega}=[P\ Q\ R]^T$ and $\boldsymbol{V}=[U\ V\ W]^T$ vectors properly: angular and linear velocities of aircraft in the aircraft coordinate system, and

$$J = \begin{bmatrix} I_x & 0 & -I_{xz} \\ 0 & I_y & 0 \\ -I_{xz} & 0 & I_z \end{bmatrix} \tag{2}$$

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is the constant inertia matrix, including the existence of an aircraft symmetry plane *Oxz*. The above equation system is derived from the well-known (Stevens et al., 2016) and (Cook, 2007) kinematic equations, facilitating the calculation of aircraft orientation angles (Euler angles) Θ,Φ,Ψ and aircraft location $x_g y_g z_g$, in the assumed, inertial reference system $O_0 x_g y_g z_g$.

Eliminating two complementary systems, i.e. the thrust control system and the breaking control system, is useful for automatic taxiing direction control system integration purposes. In equation systems (1), this simplification allows us to assume that the forces and moments of forces generated by the aircraft power plant, breaking system and tire friction are equalised. In this case, the following forces and moments of forces have an effect on aircraft movement: aerodynamic forces $\boldsymbol{F}_a$ and moments of forces $\boldsymbol{M}_a$, undercarriage forces $\boldsymbol{F}_g$ and the force of gravity $\boldsymbol{F}_c$.

During the aircraft taxiing phase, the occurrence of a non-zero angle of flow in the *Oxy* plane depends on two factors: wind and wheel slippage, and is equivalent to the sideslip angle during non-stationary flight. By analogy, this angle is called slip angle β. Considering that aircraft velocity during taxiing is comparable to or even lower than wind velocity, the value of the resulting slip angle β can range between -180° and 180°. There is a substantial difference between the taxiing phase and the steady flight phase when the values of slip angles vary by only a couple or many degrees.

The aerodynamic forces and moment of force coefficients have been calculated from wind tunnel test data and CFD calculations (Placek et al., 2017.) Aircraft flow direction was determined using slip angle β and local angle of attack α_p. Local angle of attack α_p is the angle between the aircraft flow vector and the *Oxy* plane. These angles can be calculated as:

$$\beta = tan^{-1}\left(\frac{V_a}{U_a}\right) \tag{3}$$

$$\alpha_a = tan^{-1}\left(\frac{W_a}{\sqrt{U^2_a+V^2_a}}\right) \tag{4}$$

where: $U_a V_a W_a$, are the components of aircraft flow resulting from aircraft motion and wind velocity.

These aerodynamic coefficients allow us to calculate both forces directly affecting aircraft motion and the component of the pressure force of each undercarriage wheel to determine friction. The chosen aerodynamic coefficients, having a substantial effect on aircraft taxiing, c_y c_z, c_{mt}, c_n have been shown in the Figure 3.

The influence of the F/A-18 aircraft's three-leg undercarriage with front wheel has been taken into account by incorporating forces $\boldsymbol{F}_{g_n z}$ for *n=1,2,3*, generated by each of the three undercarriage legs, into the model. They have been modelled as the spring-damper system (Baarspul, 1990):

$$F_{g_n z} = - k_n \delta_{g_n z} - c_n \delta_{g_n z} \tag{5}$$

where: k_n – elasticity coefficient, c_n – dumping coefficient, $\delta_{g_n z}$ – vertical deformation of the undercarriage element.

The values of vertical forces generated by each of the aircraft's legs allow us to calculate the side force generated at the contact point of each tyre and the ground, using the following function, depending on tyre type:

$$F_{g_n y} = F_{g_n y}(\zeta_n, F_{g_n z}, \tau) \tag{6}$$

where: τ – coefficient depends on the condition of the taxiway, scaling the side force on the wet/icy/snow covered taxiway in comparison with the dry taxiway (Krawczyk et al., 2019), ζ_n – tyre slip angle evaluated for each wheel,

$$\zeta_1 = tan^{-1}\left(\frac{V+Ra}{U}\right) - \delta_n$$

$$\zeta_2 = tan^{-1}\left(\frac{V-Rb}{U+R\frac{c}{2}}\right) \tag{7}$$

$$\zeta_3 = tan^{-1}\left(\frac{V-Rb}{U-R\frac{c}{2}}\right)$$

where: δ_n – front wheel deflection angle, a – the distance between the front wheel and the projection of the aircraft's center of gravity on the *Oxy* plane, b – the distance between main wheels, c –wheelbase.

The force of gravity components in the *Oxyx* coordinate system depends on aircraft orientation:

$$F_c = mg \begin{bmatrix} sin\Theta \\ sin\Phi cos\Theta \\ cos\Phi cos\Theta \end{bmatrix} \tag{8}$$

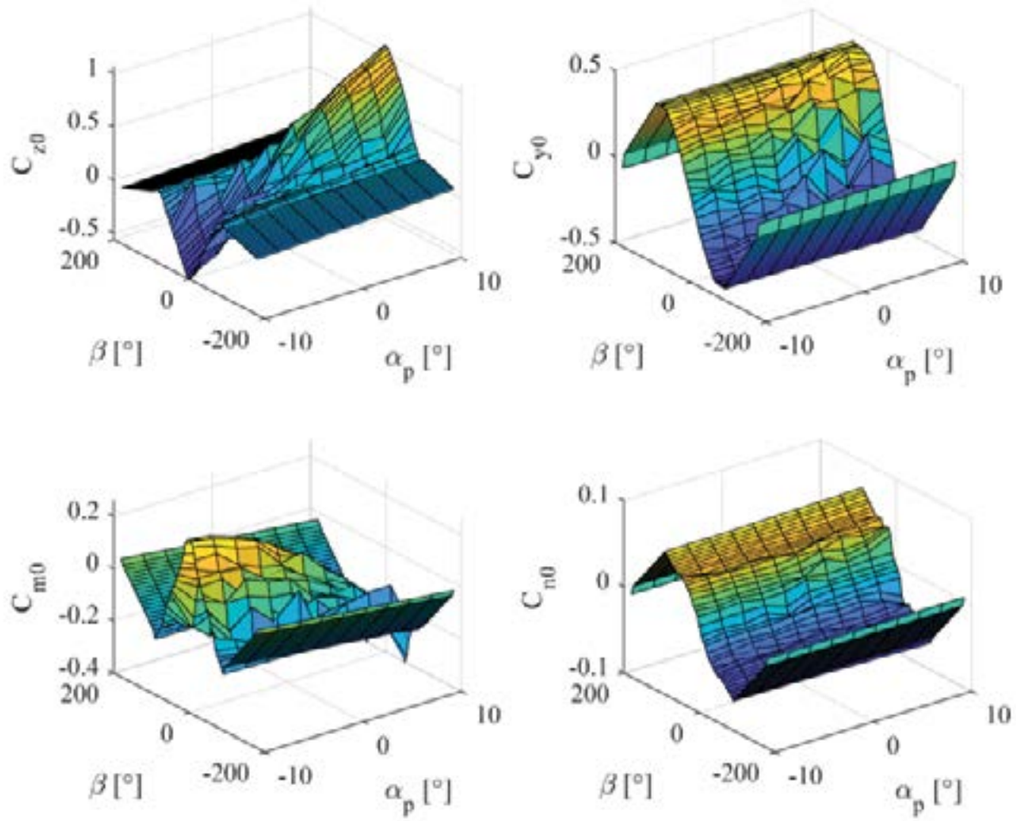

Figure 3.
Aerodynamic coefficients as functions of slip angle and local angle of attack.

3. AUTOMATIC TAXIING CONTROL SYSTEM

The control algorithm presented in this paper is a part of an automatic taxi control system (Zajdel et al., 2017). The proposed general structure of the system (Figure 4) is inspired by the structure of contemporary flight control systems. The system consists of a high level controller that tracks reference trajectory, the generation of yaw angle and speed reference for the low level controller. Its role is equivalent to that of the Flight Management System. The low level controller contains the control algorithm and is responsible for steering the aircraft by tracking reference values of the required quality. Its role is equivalent to that of an autopilot.

The choice of the control algorithm was based on the analysis of the known algorithms in terms of compliance with the three criteria shown in Table 1.

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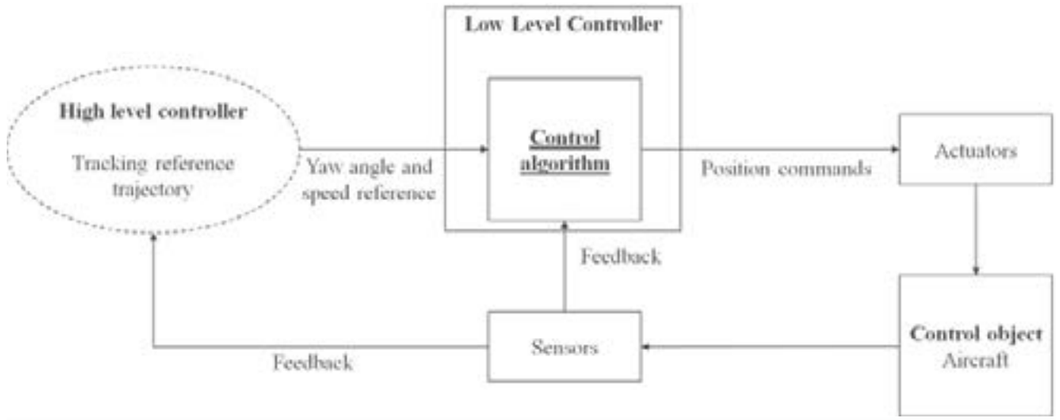

Figure 4.
General structure of the Automatic Taxiing Control System.

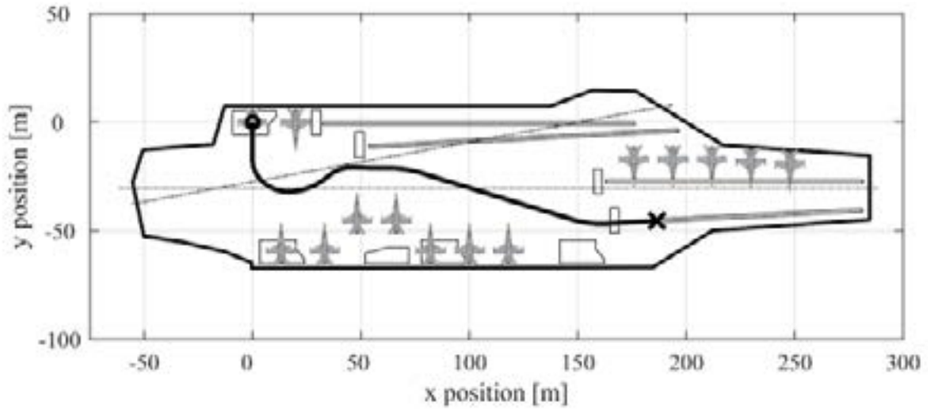

Figure 5.
Aircraft trajectory during automatic taxiing using ADRC direction control algorithm.

Table 1.
Results of control algorithm analysis.

Control algorithm	Is robust to model uncertainties	Can be synthetized with nonlinear model	Does not need full state feedback
PID with gain scheduling	X		X
LQR	X		
NDI		X	
H_∞	X		X
MRAC, MIAC		X	X
MPC	X	X	X
LPV	X		X
Backstepping		X	
Sliding Mode	X	X	X
Fuzzy Logic	X	X	X
Neural Network	X	X	X
ADRC	X	X	X

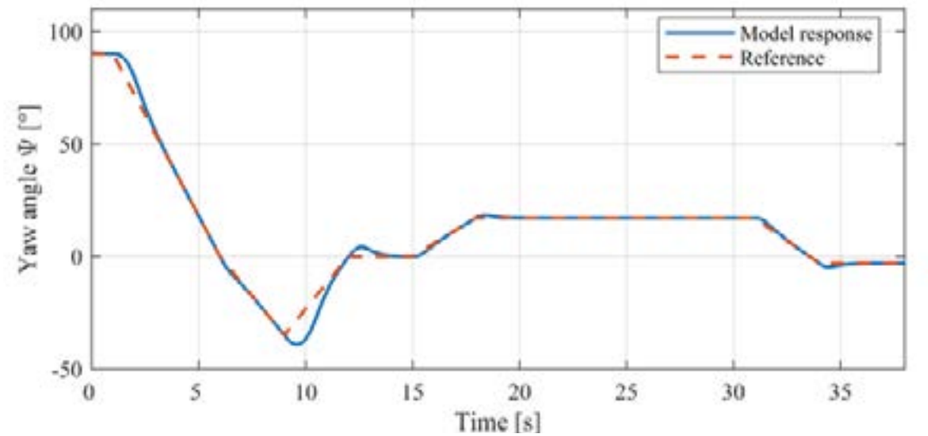

Figure 6.
Yaw angle model response and reference yaw angle – tracking performance of ADRC direction control.

The algorithm analysis identified four candidates meeting the criteria. The ADRC (Adaptive Disturbance Rejection Control) algorithm does not suffer from issues like chattering in connection with sliding mode control, neural network training process and lack of rules for fuzzy set formulation (Zammit & Zammit-Mangion, 2014a/b). The ADRC was thus chosen as the algorithm to be used in the automatic taxiing direction control system.

The main idea behind the ADRC is to compensate disturbances by introducing an error between model output and extended state observer (ESO) output, called total disturbance in the internal feedback loop. The ESO structure reduces the model to a double integrator which includes total disturbance as an extended state. This approach ensures robustness in the presence of model uncertainties and simplifications (Han, 2009), (Gao, 2006).

The ADRC was applied as a directional control algorithm that tracks the reference yaw angle by turning the nose wheel of the F/A-18 aircraft model presented in the preceding chapter. It was tested in a taxi scenario on the carrier deck in the arrangement called "flex deck" - used when take-offs and landings are performed simultaneously. The waist and the stern of the ship are used for landing, whereas bow cat 1 is used for take-offs (The Arrangemet…, 2019), (NATC, 2014).

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Figure 5 illustrates the resulting trajectory of the aircraft taxiing from elevator 4 to catapult 1 by crossing the landing area and manoeuvring between parked F-18 aircraft. Figure 6 shows the yaw angle tracking performance of the ADRC algorithm. The nose wheel command signal and nose wheel angular position are shown in Figure 7.

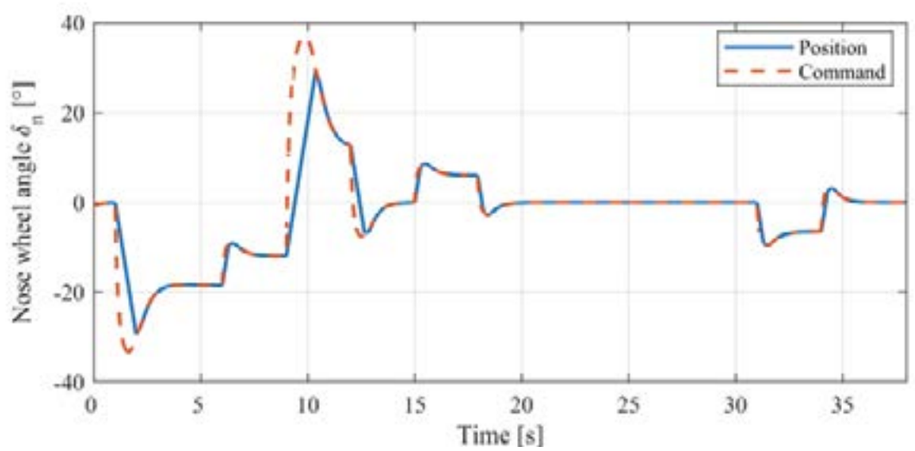

Figure 7.
Nose wheel angular position commanded by the ADRC directional control and its measured position.

4. CONCLUSIONS

The presented results of simulation tests suggest that the ADRC control algorithm can be successfully used in a carrier-based aircraft automatic taxiing control system. The aircraft tracked the reference yaw angle with satisfactory performance, as the aircraft followed the desired taxi route. In the sharpest turns on the simulated taxiing route, the front wheel servomechanism speed saturated for a few seconds. The yaw angle tracking performance in these moments could be improved by using faster front wheel servomechanism.

Taking into account previous research (Krawczyk et al., 2019), (Zajdel et al., 2017) on automatic taxiing direction control system for ultralight aircraft showed the ADRC algorithm to also be suitable for use in the said system in aircraft having significantly different parameters.

The automatic taxiing of aircraft, particularly unmanned, on the airfield or carrier deck, is a challenge facing present-day aeronautic specialists. The introduction of such systems requires the solving not only of technological, but also of organisational, legal and operational issues connected with this phase of aircraft operation.

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Stability Assessment of Drill Ship Using Probabilistic Damage Stability Analysis

Poonam Mohan, A.P. Shashikala

Drill ship is a ship-shaped structure with a drilling unit at its center and with oil compartments, which is moored and kept in position using anchors. These ships should be capable of working in deep sea for a long time, hence affected by harsh ocean environment. Drill units are said to have greater heave motion, and the height of the derrick influences the vessel's stability. MARPOL Oil Outflow Analysis is performed for damaged crude oil carriers or tankers and Mobile offshore drilling units (MODU) in damaged condition. In the present study, probabilistic analysis is performed on drill ship to understand its stability behavior under damaged condition. Stability assessments are carried out by considering single and multiple damage locations. Oil outflow analysis is carried out for different damage cases of oil tank. Probabilistic damage assessment is done for load cases up to 50 % flooding, to obtain stability charts. These charts will be useful to understand variations in stability parameters under damaged conditions.

KEY WORDS

~ Damage potential diagram
~ Stability Chart
~ MODU
~ MARPOL Oil Outflow Analysis

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1. INTRODUCTION

Drill ships are designed for drilling of oil reservoirs to extract oil and natural gas in deep sea. They have drilling platform, derrick, and moon-pools on hull to drill up to a depth of 3,200 m. These vessels are designed for a water depth of 30 to 900 m when the ship movement is allowed for only 5 % of water depth. The transit speed of the vessel is around 10 knots and optimum wind speed is 70 knots in intact condition (Stability booklet, 2006). Non-linear sea states are crucial to be considered during its design as drilling unit has to be aligned perpendicular to oil bore holes in the sea bed. This involves huge effort to keep Mobile Offshore Drilling Units (MODU) stable. Mooring lines, risers, and strings are used to keep the drilling platform stable. Their response and stability parameters are highly critical in these ships. Although current SOLAS 1990 (International Convention for Safety of Life at Sea) agreement guarantees ship safety under damaged condition for passenger ships and dry cargo ships, there is no final and international rules or regulations for determining damage stability on oil carrying vessel. Hence, to evaluate survivability under flooding, regulations for dry cargo ships given by IMO 2008 (International Maritime Organization) are used for damage stability investigations.

Liquid cargo carriers face challenges like liquid property, granularity, fill level, etc. which affect motion response. Vibrations are created due to moving liquid cargo which affects the overall stability of the vessel. Ships movement is then similar to the movement of liquid under the influence of free surface effect. Drill ships have mud carrier tanks, oil tanks and brine tanks which affect its stability under intact and damaged condition.

When damage occurs on a crude oil carrier due to environmental issues, oil outflow occurs and the stability of the vessel is affected. Extent of flooding and leakage depends on the location of damage, oil fill height, and draft. The oil carrying containers are designed in such a way that the external pressure is lower than internal pressure. This helps to prevent water ingress from the sea, but it promotes oil outflow. If the tank is partially filled, water ingress can also take place. In most cases, the tanks are fully loaded. The present study aims to prepare the stability chart for the damage condition of the drill ship, which will be an effective tool to evaluate the final stability and serviceability of the ship in probable damage cases.

2. REVIEW OF PREVIOUS WORKS

To understand the actual scenario of damage stability, researchers started investigating flaws which caused previous accidents, for safety improvement. Shipping industry has reacted after various disasters where a ship lost its watertight integrity. They tried in many ways to improve current regulations like IMO's SOLAS. Researches on damage stability assessment of ship when subjected to ocean environment and its survivability need to be constantly improved as it an unpredictable phenomenon.

Cheng et al (2010) studied the dynamics of spillage during the damaged condition of an oil carrier. Moving Particle Semi-Implicit (MPS) method was adopted using numerical code SSTAB. Coupling between the damaged hull response and internal multiphase flood dynamics was carried out. A two-dimensional small-scale model undergoing sway motion with induced high volume oil leakage was compared with numerical results. The final list angles were obtained numerically for large filling ratio and height. At filling ratio 45 %, a noticeable difference was observed in the final list angle when numerical results were compared. A study about oil outflow from different types of tanks was conducted by Tavakoli et al. (2011). The tanks considered were either below or above waterline during collision and grounding incidents. They verified the performance of the proposed model using CFD simulations and experimental tests. They concluded that the ship with double hull is most efficient and helps reducing oil spill. Begovic et al. (2013) showed variation in motion responses when a ship's hull is damaged, and highlighted scaling issues and effects while modelling. Hashimoto et al. (2014) used moving particle semi-implicit method to simulate flooding of damaged ship for beam wave. The ordinary strip method based on potential flow theory was adopted to check the results. It was confirmed that Boyle's law can qualitatively predict multiphase dynamic effect between air and water during flooding. A new numerical flood simulation tool which allows evaluation of a ship's time dependent damage stability including all stages of flooding was developed by Lorkowski et al. (2014). Lee et al. (2015) performed a set of model tests in intact and damaged ship considering six degrees of freedom in beam seas. When starboard side damage opening faces the sea, heave and roll motion changes drastically. At the region near damage, free surface effect was strongly coupled with the roll motion of the ship. Manderbacka et al. (2015) experimented to bring out effects of coupling ship motion and flooding in a box-shaped barge model. Flooded water behaved in a different manner in undivided and divided compartments. In divided compartments, flooded water increased roll damping significantly. Onset of flooding suddenly after damage is difficult to be modelled as it is highly nonlinear and varies with different internal layouts of compartments. This can give unpredictable roll response. Acanfora and Luca (2016) conducted experiments on damaged vessels in still water to find roll response in beam waves. Side and bottom damage was investigated, which generated greater roll damping. Moreover, roll period was less for bottom damage case. It is affected by type and position of the damaged compartment. Sway motions were significantly reduced during damage. They also stated that wave frequency fluctuated for different wave height due to nonlinear sea states during different damage scenarios.

In the present study, damage locations were identified, and the probability of failure of the vessel due to compartmental flooding is found out in terms of probability index. Stability charts were developed related to stability parameters. It focuses on damage analysis of oil compartments, which will be helpful in monitoring oil outflow effects on stability.

3. THEORETICAL BACKGROUND

The IMO Code specifies a set of vertical center of gravity (VCG) value for different drafts of drill ship. To study intact stability of drill ship, properties like compartmental arrangement, subdivision plan, ship line plan, loading conditions, and hydrostatic characteristics are to be known. To assess damage stability, permeability of rooms and void spaces are considered to be 0.95 and that of machinery rooms 0.85. Downflooding points are to be considered in damage stability assessment. Open spaces are to be considered in intact stability assessment. The codes define three stages of design for drill ships i.e. sailing, drilling, and stand-by condition. The main parameters included in the intact stability criteria are based on limiting metacentric height (GM), equalizing the righting moment and energy to its limiting value.

Damage extent shall be considered horizontally up to 1.5 m and vertical without any limits. Water tight bulkhead should be considered 3 m from the damage location. Longitudinal extend of damage considered should not exceed 3 m. The VCG obtained from the intact stability assessment is considered as initial VCG in damage stability analysis.

The maximum VCG is obtained under loading condition during the operational stage of drill ship. It should satisfy stability and integrity conditions specified in DNV-OS-301. Probabilistic analysis is undertaken to assess the damage stability of drill

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ships. To prevent oil pollution occurring due to ship damages, MEPC.117 (52) has provided the outflow parameter O_(M), which is the total volume of oil cargo in m3 at 98 % tank filling C. The ship is loaded up to load line draft ds without trim or heel for the calculation of mean oil outflow parameter. The measurement of outflow is affected by tank permeability. It is different for different cargo spaces in a ship. In general cases like cargo tanks, ballast tanks, machinery room, engine room etc. permeability is taken as 0.99. The oil outflow is measured separately for hull side and bottom failure cases. The oil outflow for both cases is combined to get a dimensionless parameter OM which is represented as:

$$O_M = (0.4\, O_{MS} + 0.6\, O_{MB}) / C \quad (1)$$

Oil outflow due to side damage is OMS and oil outflow due to bottom damage is OMB, both measured in m3. The oil outflow for side damage OMS is given by:

$$O_{MS} = C_3 \Sigma_i^n P_{S(i)}\, O_{S(i)} \quad (2)$$

Here, probability PS(i) of oil tank i is found and the corresponding oil outflow OS(i) is measured in m3 for side damage when filled 98 %. This is performed for n number of oil tanks. The tank filling C3 is taken as 0.77 for ships having two adjacent horizontal bulkheads inside cargo tanks and 1.0 for all other ships. Mean outflow for bottom damage is given by:

$$O_{MB(0)} = \Sigma_i^n P_{B(i)}\, O_{B(i)}\, C_{DB(i)} \quad (3)$$

In bottom damage, probability PB(i) of oil tank i is found and the corresponding oil outflow OB(i) is measured in m3 for side damage when filled 98 %. This is performed for n number of oil tanks. The factor to account for oil capture is CDB(i). In the probabilistic approach, degree of subdivision of a ship is considered sufficient if it meets the requirements of SOLAS criteria and attained survival probability index Ai is not less than required subdivision index (Ri).

$$A_i > R_i \quad (4)$$

Probabilistic damage stability (PDS) approach relies on statistics and involves uncertainty and random variables to describe the behavior of the vessel. Random variables may be mass, velocity, dimension, permeability etc., which might be different for different ships. If two ships have same attained index Ai , then it is considered safe. The portion of the ship below water line ds is affected by the subdivision length LS and reserve buoyancy. Required index is calculated based on ship type, and the procedure varies for each ship type. It depends on ship's length, number of persons on board, and rescue boat weight for passenger ships. It solely is a function of ship length in case of cargo ships. Drafts at 100 % loading and 60 % loading condition are represented as dp and dl. Stability on damage depends on damage location, number of damages between bulkhead, boundary of transverse and longitudinal distance to damage point, etc.

Minimum value of probabilistic stability is found out using parameter Ai. The probability index pi for zone i is found by not including longitudinal and transverse subdivisions. Horizontal subdivision can generate other flooding scenarios. Producing an attained index Ai requires three loading conditions:

$$A_i = \Sigma\, p_i x\, s_i \quad (5)$$

$$A_i = 0.4A_s + 0.4A_p + 0.2A_l \quad (6)$$

Here, s, p, l are three loading conditions which are multiplied by factors. The pi factor depends on the geometry of the ship and its compartmental arrangement. The geometry of each ship deck and initial draft is represented by vi factor. It shows that each deck or horizontal subdivision has a probability not to be flooded. Figure 1 shows PDS diagram comprising of single and multiple compartment damage cases for zone 1 to 7. (IMO; 2008) Single damaged zone (n=1)

$$p_{j,1} = p\,(x_{1f}, x_{2j}) \quad (7)$$

Two damaged zone (n=2)

$$p_{j,2} = p\,(x_{1f}, x_{2j+1}) - p(x_{1f}, x_{2j}) - p(x_{1j}+1, x_{2j+1}) \quad (8)$$

Three or more zones (n=3)

$$p_{j,n} = p(x_{1j}, x_{2j+n-1}) - p(x_{1f}, x_{2j+n-2}) - p(x_{1j+1}, x_{2j+n-1}) + p(x_{1j+1}, x_{2j+n-2}) \quad (9)$$

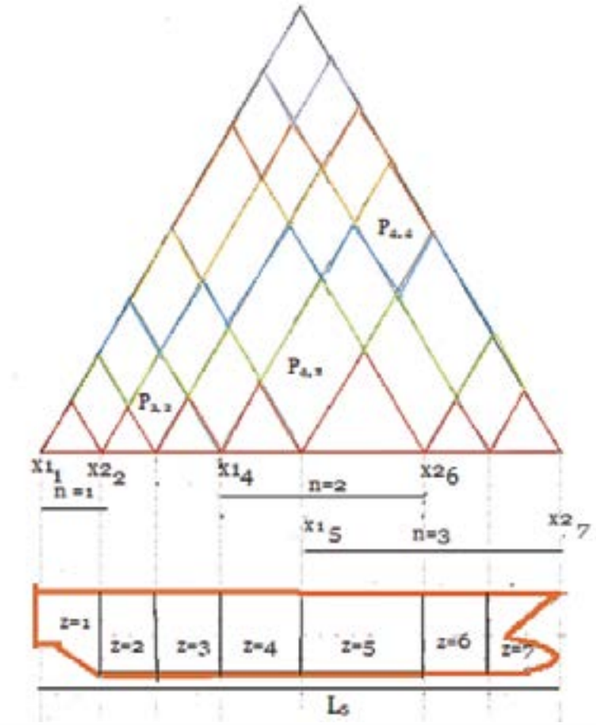

Figure 1.
Probability chart for damage cases (Explanatory notes SOLAS, 2008).

Highlight of this work is to develop damage stability charts which will be useful to the ship master for predicting a damage with regard to the probability of occurrence of damage as well as to get an idea about how much pollution will be caused to environment through oil spillage because of the damage condition. Oil outflow charts will be helpful in understanding ship survivability after a damage.

Figure 2a.
Drill ship (Stability booklet, 2006).

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4. STABILITY ASSESSMENT OF THE DRILL SHIP

4.1. Details of the Drill Ship

In the present study, a drill ship (Figure 2a) is used to study the stability characteristics in both intact and damage conditions. The general arrangement of the ship is shown in Figure 2b and its hull form properties are as shown in Table 1. The drill ship is having tanks and compartments as listed in Table 2. Compartmental arrangements are unsymmetrical. It comprises of double bottom, moon-pool, engine room, forward and aft pump room etc.

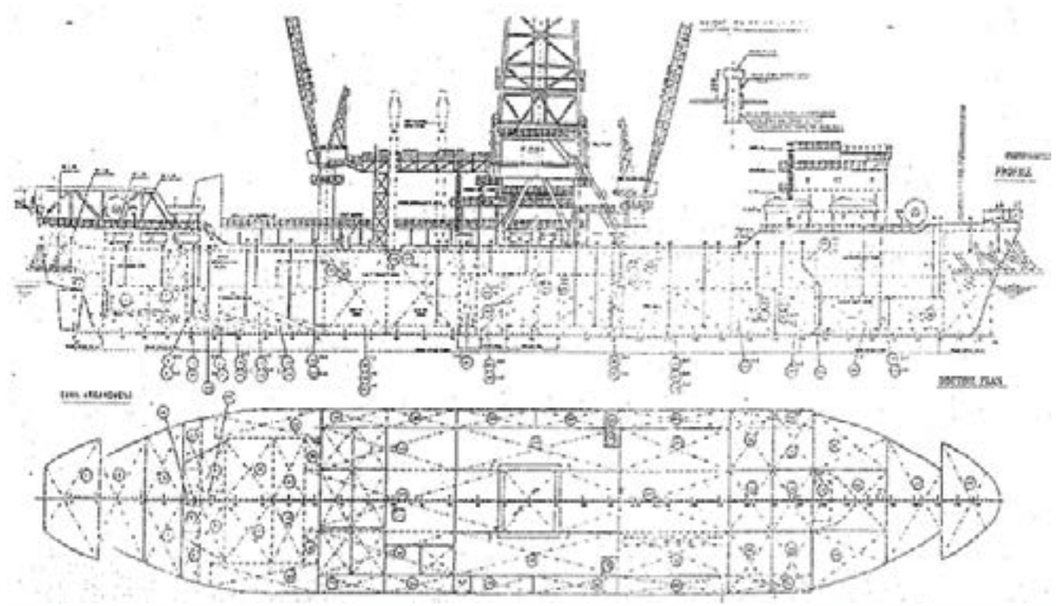

Figure 2b.
General arrangement of ship (Stability booklet, 2006).

Table 1.
Drill ship hull form properties (Stability booklet, 2006).

Parameters	Value
Length b/w perpendicular (m)	136.80
Block Coefficient	0.7526
Overall Length x Breadth x Moulded depth (m)	145.9 x 24.5 x 11.20
Vessel Type	Drill Ship
Summer DWT (t)	17426
LCG from AP (m)	64.877

Table 2.
Drill ship tanks and compartments (Stability booklet, 2006).

NAME	TYPE	INTACT %	DAMAGE%	DENSITY	FLUID
Aft Thruster port/stb	Compartment	100	100	-	-
Engine Room Port/stb	Compartment	100	100	-	-
Switch Room Port/stb	Compartment	100	100	-	-
Cofferdam port/stb	Compartment	100	100	-	-
Slop tank port/stb	Tank	100	95	0.913	-
Oil 4/ Oil 3/ Oil 2	Tank	100	95	0.8883	Crude
Access port/stb	Compartment	100	100	-	-
Base Oil	Tank	100	95	0.92	Oil
Brine	Tank	100	95	1.025	Sea Water
Aft Pump Room Port/stb	Compartment	100	100	-	-
MoonPool	Compartment	100	100	-	-
Fwd Pump Room Port/stb	Compartment	100	100	-	-
Brine	Tank	100	95	1.025	Sea Water
ROV	Non-Buoyant Vol.	100	100	-	-
Fore Peak	Compartment	100	100	-	-
Double bottom 9/10/11/12	Tank	100	95	1.025	Water
Double bottom 8/7/6/5	Tank	100	95	1.025	Water

An effective way to improve survivability of a vessel is to have a longitudinal bulkhead. Most oil carriers have central cargo tanks without any separating longitudinal bulkhead through the middle. This arrangement can improve vessel survivability under damaged cases.

4.2. Model Details

The ship is modelled as a monohull in Maxsurf modeler (Figure 3), which contains tanks and compartments (Stability booklet, 2006) as shown in Figure 4. The ship has 6 degrees of freedom, three translations and three rotations which include surge, sway, heave as linear motions about x,y,z axis, and roll, pitch, yaw as angular motions respectively. The modeling is done about a reference point by setting out the ship dimensions along the reference frame. The markers and control points together form smooth nurbs which generate the hull surface. The volume and the displacement are set as per the data given in the stability booklet (Stability booklet, 2006). The longitudinal zone divisions (Figure 5) are applied along length Ls. It is provided with one central longitudinal and twelve transverse bulkheads, each representing extent of zones, dividing overall length into 9 zones.

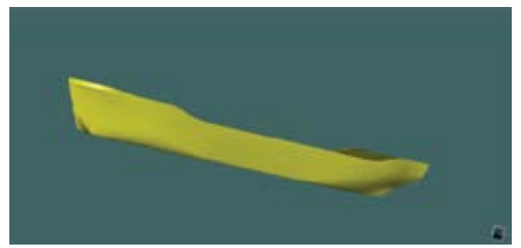

Figure 3.
Drill Ship model (source: authors).

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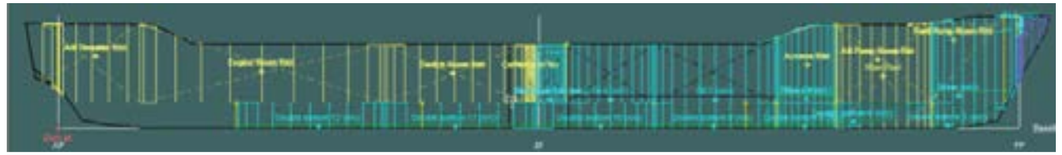


Figure 4.
Arrangement of tanks and compartments (source: authors).

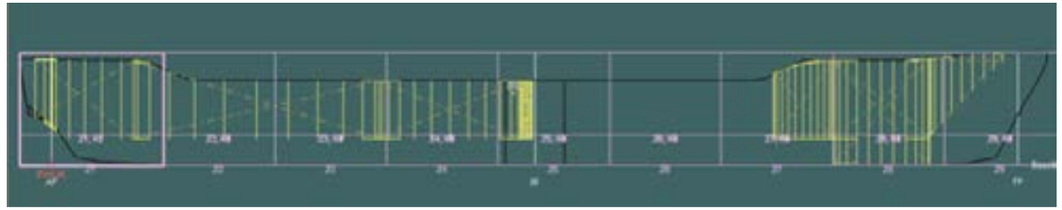


Figure 5.
Zones for damage stability assessment (source: authors).

Zone 1 is located at the bow of the vessel, close to the forward perpendicular. The analyses are done for single and multiple compartment flooding. Transverse damage extent is taken as B/5 and B/2 of the ship's beam.

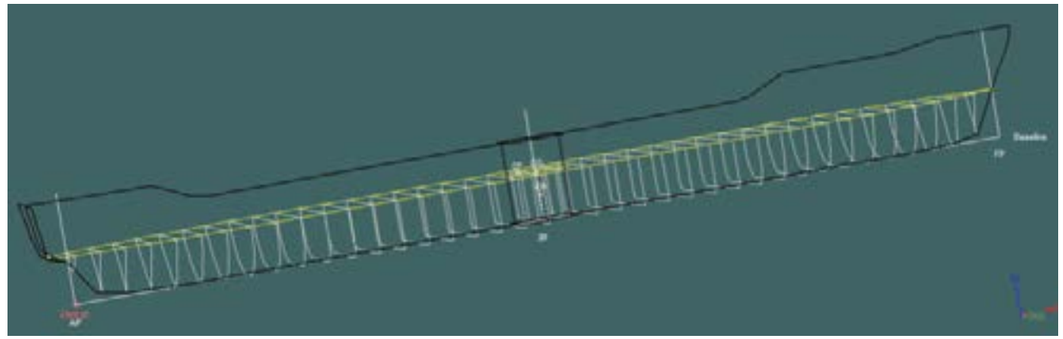
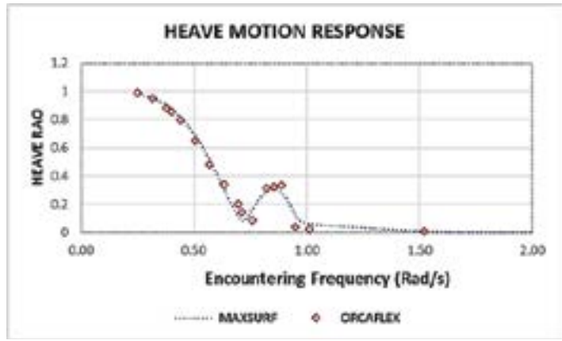


Figure 6.
Strips generated for motion analysis (source: authors).

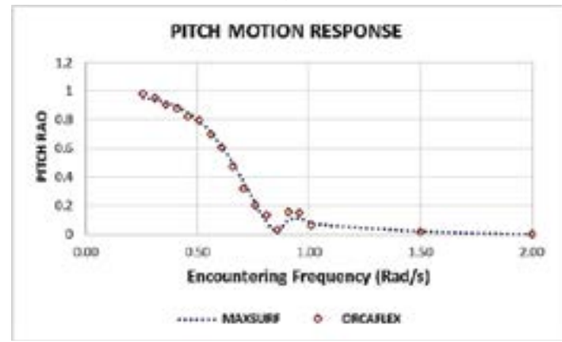
The section of the vessel below the waterline is discretized into 43 strips to perform the motion analysis (Figure 6). The strips are two-dimensional planes, for which response equations are solved. Response coefficients of each strip is then integrated throughout the ship to obtain response amplitude operator (RAO). Input parameters include the speed of the ship, wave height and the direction of wave encounter.

4.3. Motion Response Analysis

Sea keeping analysis is done based on strip theory using Maxsurf, where heave, pitch, and roll responses are evaluated. The analysis is done to obtain response amplitude operator (RAO) for small wave height, and the fluid is considered inviscid and irrotational. Encountering frequency varies from 0.2 to 2 rad/s. Encountering wave is considered in head and beam directions for linear wave height. In the operating condition, wave height is considered as 4.25 m for the analysis (Stability booklet, 2006). The response obtained is shown in Table 3. Maxsurf result is compared with those in the stability booklet (Stability booklet, 2006), which is done using an analysis tool ORCAFLEX. Heave and roll responses in beam sea, and pitch in head sea conditions are shown in Figure 7 (a,b,c).



a)



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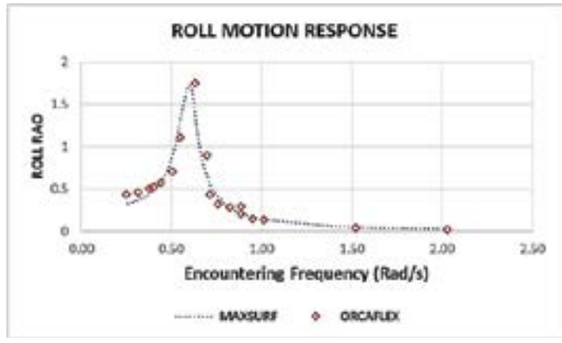

c)

Figure 7.
Response of drill ship (a) beam-heave (b) head-pitch(c) beam-roll (source: authors).

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Table 3.
Motion response RAO (Source: author).

FREQUENCY	MAXSURF (source: author)			ORCAFLEX (Stability booklet, 2006)		
	HEAVE	ROLL	PITCH	HEAVE	ROLL	PITCH
0.26	0.977	0.330	0.954	0.985	0.433	0.982
0.31	0.952	0.368	0.942	0.950	0.462	0.955
0.36	0.923	0.410	0.927	0.883	0.505	0.905
0.41	0.872	0.483	0.901	0.853	0.525	0.881
0.46	0.774	0.659	0.848	0.799	0.574	0.823
0.51	0.652	0.999	0.779	0.650	0.708	0.799
0.56	0.579	1.317	0.736	0.481	1.114	0.699
0.61	0.409	1.720	0.630	0.390	1.748	0.610
0.66	0.221	0.936	0.500	0.199	0.902	0.473
0.71	0.082	0.552	0.348	0.079	0.432	0.201
0.76	0.123	0.449	0.268	0.096	0.318	0.200
0.81	0.254	0.321	0.111	0.299	0.295	0.133
0.86	0.307	0.245	0.022	0.32	0.212	0.034
0.91	0.240	0.195	0.100	0.232	0.290	0.155
0.96	0.086	0.161	0.112	0.076	0.142	0.150
1.01	0.059	0.135	0.073	0.023	0.134	0.065
1.50	0.009	0.048	0.020	0.006	0.040	0.018
2.00	0.002	0.026	0.000	0.002	0.022	0.000

Roll resonant peak is obtained at a maximum of 1.72 for a frequency of 0.61 rad/s. A second peak is observed in heave response in beam sea and pitch response in head sea at an encountering frequency of 0.91 rad/sec. Motion response analysis predicted similar behavior as given by ORCAFLEX; hence, the designed model may be used for damage stability and oil outflow analysis.

4.4. Hydrostatic Stability Properties

At fully loaded condition, the vessel displacement is 17,426 t and the corrected distance between keel and center of gravity (KG) including free surface effect is 9.04 m. The heel angle corresponding GZ value is obtained by performing the hydrostatic analysis. GZ value (Table 4) obtained in Maxsurf is compared with ORCAFLEX, as shown in Figure 8. On performing stability analysis, the vessel's hydrostatic properties were obtained.

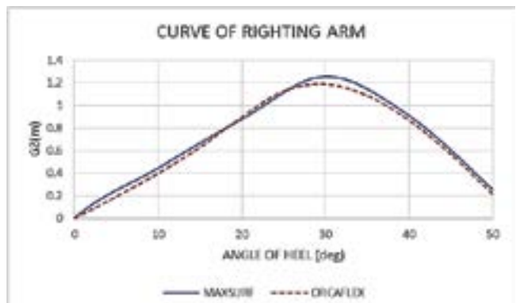

Figure 8.
Hydrostatic stability curve of Sagar Vijay (source: authors).

Table 4.
Righting arm obtained in stability analysis (Source: author).

HEEL	RIGHTING ARM, GZ (m)	
	MAXSURF	ORCAFLEX(Stability booklet, 2006)
0	0	0
10	0.445	0.4
20	0.879	0.898
30	1.258	1.19
40	0.91	0.869
50	0.255	0.215

Table 5.
Hydrostatic properties (Source: author).

PROPERTIES	VALUE	UNIT
Maximum draft	6.72	m
Vertical center of gravity	12.54	m
Longitudinal center of gravity from aft perpendicular	64.877	m
Transverse center of gravity	0.253	m
Maximum heel angle	30°	-
Maximum GZ value	1.2	m

On validating the model, based on hydrostatic and hydrodynamic properties, the probabilistic damage stability analysis is performed.

4.5. Probabilistic Damage Stability Assessment

The damage stability analysis is carried out for all tanks at the periphery of the vessel and also for those double bottom tanks exposed to water. It is necessary to know the serviceability of the vessel after a damage condition, which is dependent on draft as well as displacements of the ship. To study variations in the stability due to ship damage-induced flooding, nine load cases have been created. Load cases considered are intended and defined for the proper functioning of the vessel, which are as given in Table 6.

The probability of flooding was found for tanks and compartments, and those lower than 0.01% were neglected. A total of 10 major damage configurations were considered in oil compartments. Damage cases and its probability of getting flooded are listed in Table 7. The compartment like oil 3, oil 2, oil 4, and double-bottom tanks 12, 11,10,9,8,7,6, as listed in Table 2, were damaged to obtain the probability index.

Table 6.
Load case definitions (Stability booklet, 2006).

Load case	Displacement (t)	Draft (m)
Load case 1	8,651	4.167
Load case 2	9,645	4.223
Load case 3	9,788	4.503
Load case 4	10,503	4.780
Load case 5	11,217	5.055
Load case 6	11,931	5.327
Load case 7	12,646	5.397
Load case 8	13,360	5.889

The probabilistic damage stability plot for single and multiple flooded compartments is as shown in Figure 9. It is a triangular plot with the lowest row of triangles showing the effect of damage opening in zone 1. The second row of parallelograms shows damage in zones 2, 3 and 4 when flooded simultaneously, which is the combination of multiple compartmental damages.

The probability factor or p-factor for different damage cases is assessed in terms of Attained index. The color coding helps to define sections of the ship which are highly susceptible to occurrence of damage. Longitudinal Subdivision Ls has a limitation of how the zones are defined to maximize the Attained Index Ai. The p-factor varies when damage length changes. The Damage Potential Diagram (DPD) can help the designer in finding out damage zones, which have the largest potential for the attained index.

DPD compares the maximum attained index for a selected number of zones to the total attained index for all the zones. The first set represents 'Ai' at the deepest subdivision draft or summer load line, the second set represents 'Ai' at a partial subdivision draft, and the third set represents 'Ai' at zero loading draft condition.

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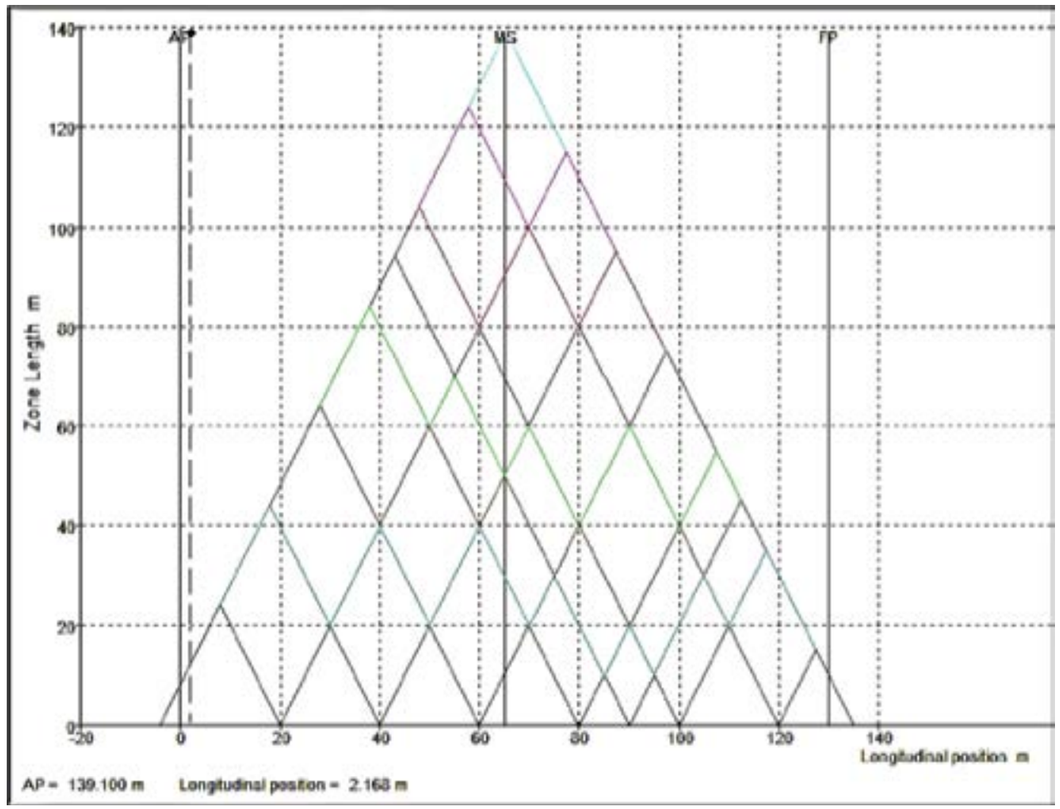
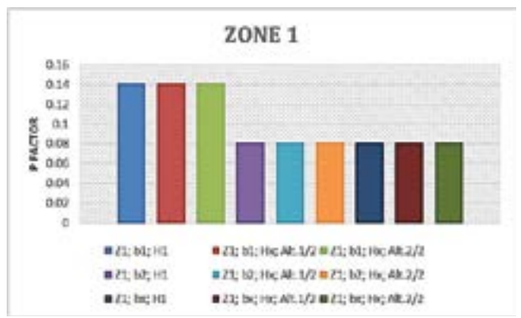
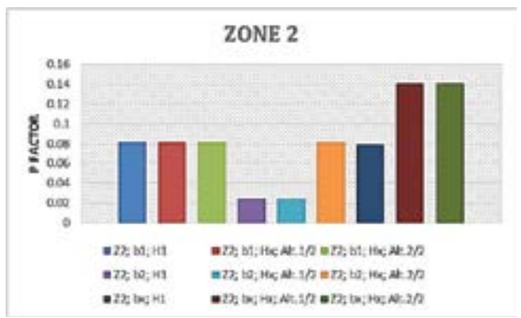
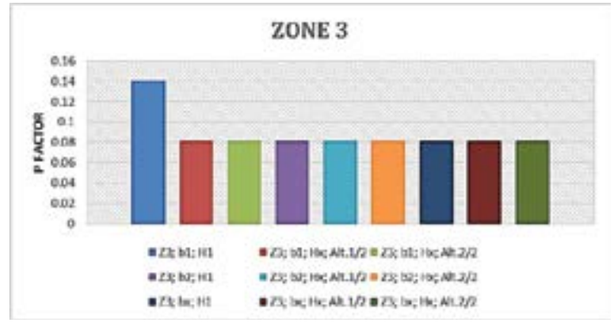
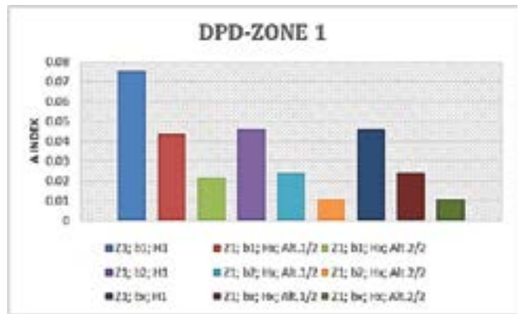


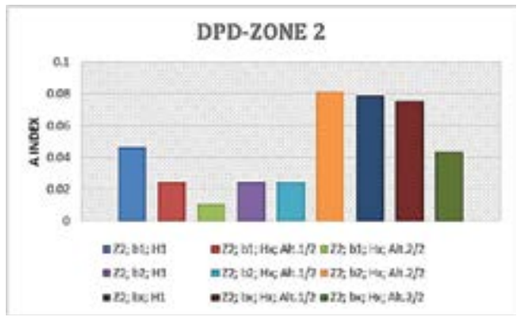
Figure 9.
Probabilistic damage stability plot (source: authors).











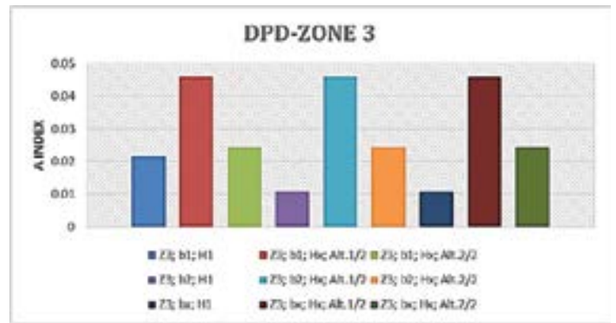


Figure 10.
P-factor and Damage Potential Diagram for Zones 1 to 3 (source: authors).

The effects of damage on attained index in different zones are plotted in Figures 10,11 . In case of the drill ship in fully loaded condition, the attained index is 0.53782, which is greater than the Required Index 0.5046. Hence, the criteria for damage stability are fulfilled according to MSC 216-82.

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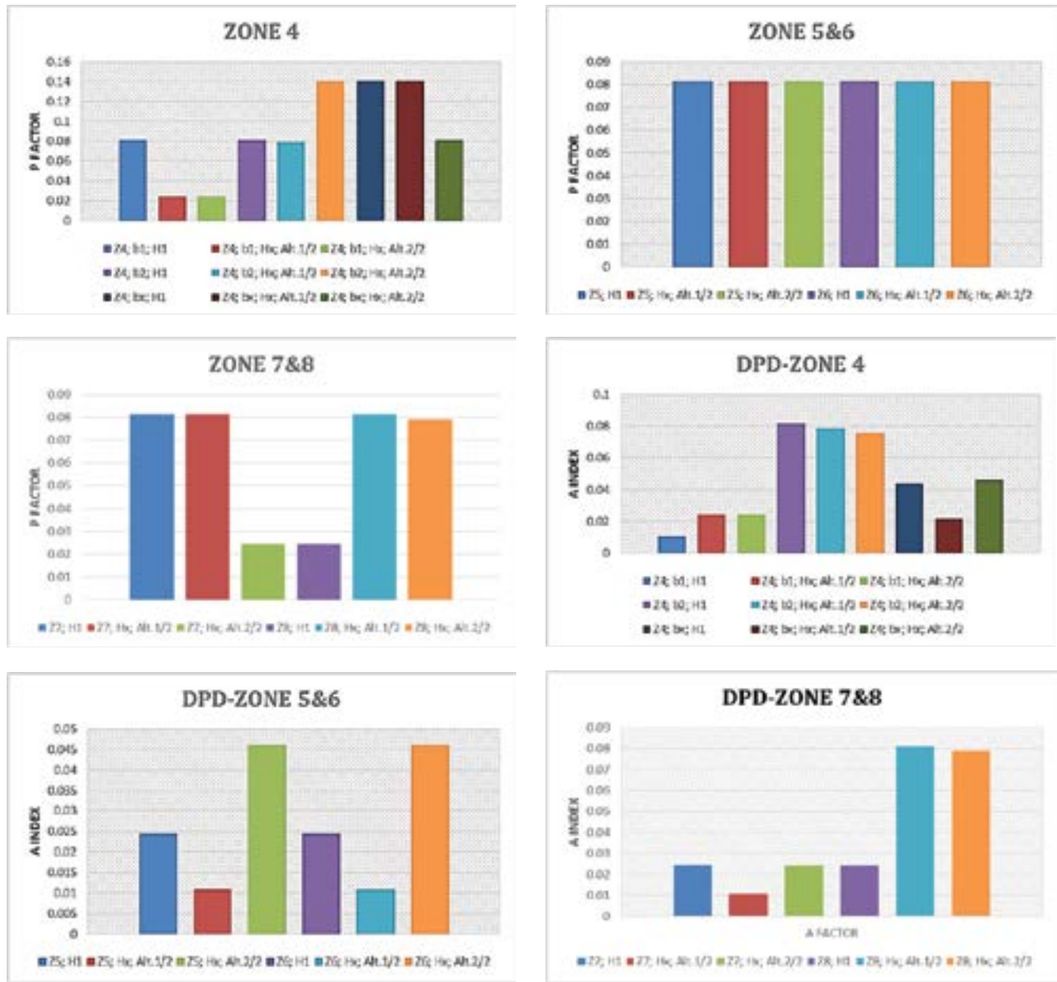

Figure 11.
P-factor and Damage Potential Diagram for Zones 4 to 8 (source: authors).

5. MARPOL OIL OUTFLOW ANALYSIS

Slop tanks are used to store oily water mixture from cargo tank washing. There are two slop tanks, six double bottom tanks, nine oil and brine carrying tanks inside the vessel (Table 7). Marpol oil outflow analysis is done based on Regulation 12 A and Regulation 23 considering single and multiple combination of oil and brine tanks. The volume of oil outflow is measured and is shown in Figure 12(a-b). Further stability charts related to the same were developed.

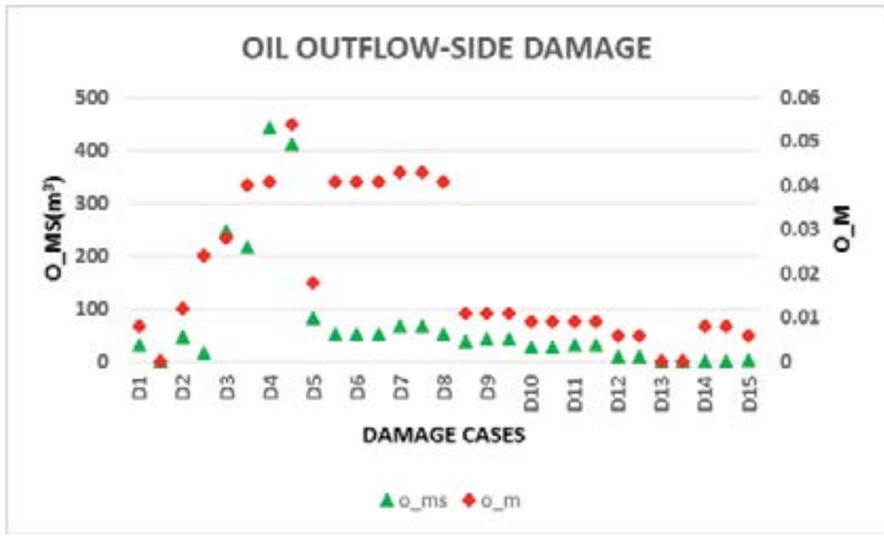

Figure 12.
Oil outflow of (a) Side damage (b) Bottom damage (source: authors).

It is found from Figure 12 that mean outflow is the maximum in damage cases D3 to D8 for side damages while in the case of bottom damage, the maximum oil outflow takes place in cases D7 to D15. It is seen that damage of double bottom tanks has less influence on oil outflow. This means that when bottom damages occur, even if double bottom tanks undergo flooding, the vessel can be stabilized. In side damage condition, oil and brine outflow begins abruptly and it becomes difficult to stabilize the vessel.

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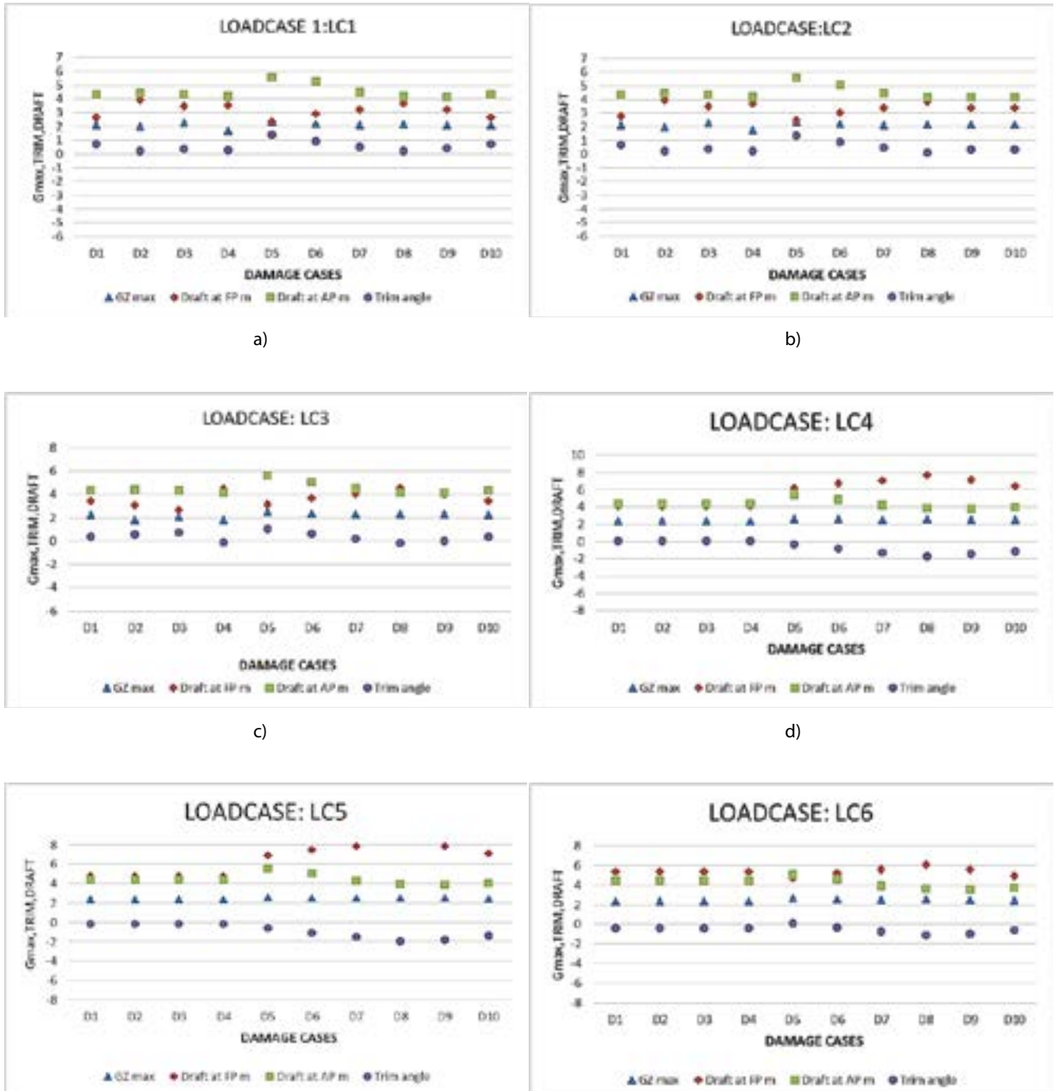
Table 7.
Damage cases (source: authors).

DAMAGE CASE	TANKS	1-BD	o_mb	o_m	2-SD	o_ms	o_m
D1	slop tank port	pass	1.495	0.004	pass	31.181	0.008
		pass	1.742	0.004	pass	0	0
D2	slop tank stb	pass	1.495	0.004	pass	46.154	0.012
		pass	1.742	0.004	fail	14.973	0.024
D3	oil4	pass	40.518	0.011	fail	246.814	0.028
		pass	44.985	0.012	fail	215.633	0.04
D4	oil 3	fail	82.212	0.016	fail	442.507	0.041
		pass	89.096	0.018	fail	411.326	0.054
D5	base oil	fail	7.136	0.009	fail	82.932	0.018
		pass	7.978	0.01	fail	51.751	0.041
D6	brine	pass	7.136	0.009	fail	51.916	0.041
		pass	7.136	0.009	fail	51.916	0.041
D7	brine	fail	78.36	0.076	fail	66.736	0.043
		fail	83.48	0.081	fail	66.736	0.043
D8	db12	pass	113.607	0.047	fail	51.916	0.041
		pass	10.848	0.004	pass	38.995	0.011
D9	db11	pass	16.284	0.006	pass	42.892	0.011
		pass	173.817	0.066	pass	42.892	0.011
D10	db10	pass	16.652	0.008	pass	27.121	0.009
		pass	191.249	0.097	pass	27.121	0.009
D11	db9	pass	26.033	0.012	pass	31.181	0.009
		fail	289.142	0.131	pass	31.181	0.009
D12	db8	pass	299.214	0.065	pass	8.808	0.006
		pass	134.518	0.142	pass	8.808	0.006
D13	db7	pass	1.792	0.018	pass	0	0
		fail	14.328	0.144	pass	0	0
D14	db6	fail	1.792	0.018	pass	1.153	0.008
		fail	14.328	0.144	pass	1.153	0.008
D15	db5	fail	15.623	0.058	pass	2.324	0.006

6. STABILITY CHARTS

Variation of GZmax of the model in damage cases for different load cases can define the behavior of the ship. As GZmax tends to zero, the righting moment to restore the rolling vessel is reduced, hence the instability. A set of results can be shown by studying draft, trim, and GZmax at the same time. Figure 13 (a)-(h) shows the variation of draft, trim, and GZmax according to damage case for each load case. These plots help to analyze the survivability of the vessel under a probable damage, according to loading of the vessel. A sudden shift of trim from positive to negative is seen in load case 4 to 8. A shift in the center of gravity is also observed due to the flooding of cargo tanks from 0 % to 40 %. Positive trim indicates that the vessel is trimmed by the stern, i.e. the draft at the stern is greater than the draft at the bow. As the load increases, the vessel is gradually trimmed by the bow for all damage cases as well as in intact condition. As the trim increases due to flooding, the vessel's serviceability is reduced.



a) b) c) d) e) f)

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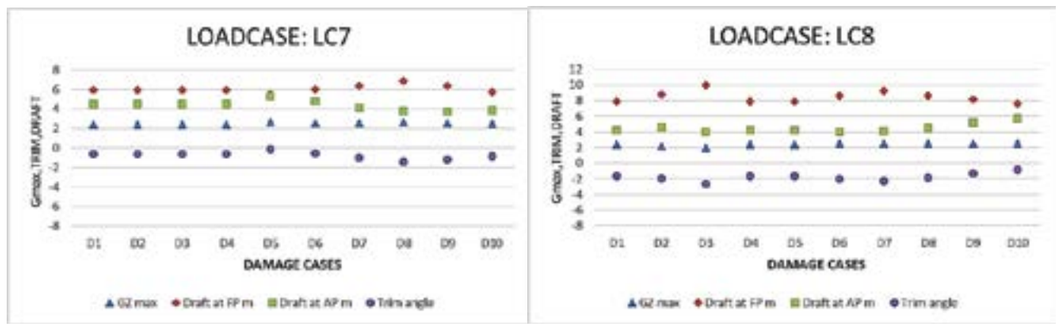

g) h)

Figure 13.
(a-h) Stability charts w.r.t. GZmax, trim, draft (source: authors).

7. CONCLUSIONS

The probabilistic damage stability analysis was done to predict the effect of tanks and compartmental arrangement on stability. The damage potential diagram showed the safety of the vessel in terms of the attained index. Oil outflow determines the stability of the vessel under damage condition. By analyzing mean oil outflow volume, we could determine stability variation based on GZ, draft and trim corresponding to the related load case and damage case. The following conclusions were obtained from the oil outflow analysis and probabilistic damage stability analysis:

1) Compartments in the trimming side are found to have greater influence on the attained index. The Damage Potential Diagram shows that the least p-factor value obtained is 0.02 and the maximum is 0.14. It is constant in zones 5 and 6. The Attained Index was obtained to a minimum of 0.01 and maximum of 0.08. There is no variation in p-factor for zones 1,3,5,6. Hence the probability of flooding is less predictable in the rest of the zones. When the Attained Index is high, there is less probability for the vessel to lose stability.

2) The maximum oil outflow under side damage condition is between 200 to 300 m3, while in case of bottom damages, it is between 300 to 400 m3. This shows that the double bottom tanks can reduce oil outflow and can stabilize the vessel. Damage cases D3 to D7 are oil and brine carrying tanks, hence side damages show greater effect on the stability variation of the vessel. In bottom damage cases, double bottom tanks D10 to D15 are greatly affected. It is clear that the double bottom tanks help to balance stability during bottom damage cases. Therefore, to improve the safety of the vessel, double bottom tanks are to be designed accurately.

3) Stability charts show a shift of trim from the positive to negative value up to 40 %. This is due to water ingress into the vessel due to damage. It was found in all the damage cases that trim occurs by the bow of the ship, while a positive trim value indicates trim by stern. As trim takes negative values, the draft of the ship in the forward end increases. The effect of load case and damage case is critical in stability analysis. In all the load cases and damage cases, GZ value balanced around a value of 2 m. The maximum trim value of 2 m is obtained, which is a limiting trim value. Beyond that value the vessel loses its stability. This shows that a slightest change in the trim can vary stability drastically.

Chances to reduce the consequences after a probable damage scenario will increase if we can predict the stability of the vessel for a set of probable damage cases. Damage stability charts and oil outflow charts will be helpful to evaluate the severity of damage and for a quick response and decision making in an early stage of flooding to represent the survivability of the vessel.

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Selection of UUV Type ROV Equipment and Cooperation System with USV "Edredon" in Protection Tasks of Ports and Critical Objects

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The article presents some of the problems associated with the use of an unmanned underwater vehicle type ROV (Remotely Operated Vehicle) to cooperate with the USV (Unmanned Surface Vehicle) "Edredon" carrying out tasks related to the perimetric protection of seaports infrastructure and critical objects. The system remote control of the underwater vehicle, requires the appropriate structure of the system ensuring the cooperation of both vehicles and the selection of the special apparatus mounted on the ROV. The tasks carried out by the both vehicles have a very high impact on the hardware solutions and cooperation of USV with an unmanned underwater vehicle.

KEY WORDS
~ USV (Unmanned surface vehicle)
~ ROV (Remotely underwater vehicle)
~ Critical infrastructure.

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1. INTRODUCTION

For the protection of critical infrastructure systems in technologically advanced countries, inter alia, unmanned radio-controlled or programmable (autonomous) surface vehicles are used. The potential of these vehicles increases significantly if they are fitted with a module containing a system for observing and conducting underwater work, which can be controlled by the operator by radio from a distant command control post. During the last dozen years, the awareness of the need to protect critical infrastructures from terrorist attacks has increased considerably. These hazards can occur from the air, the ground and the sea (above or below its surface). Figure 1 shows some of the maritime components of the critical infrastructure..

Traditionally, attention is mainly given to non-underwater threats, which relate to the main part of the resources assigned to the protection of critical infrastructure. As a result, a high level of technology against these threats can be developed, based on access to control, radar, thermal cameras, infrared cameras, etc.

The underwater threat did not have a high priority until the terrorist attacks of divers that were planned and performed, including by Argentinian divers to British ships in Gibraltar during the Falkland War. As a result of technological development, the threat of underwater attack was then small, but it quickly increased in recent years. The current trend is to ensure total environmental safety, i.e. protection of critical infra-structures, which covers all anticipated threats by creating an integrated marine environmental protection system.

Figure 1.
A few examples of critical infrastructures related to the marine environment (refinery, oil rig), (Source: Materials of projects).

The previous practice proved that unmanned underwater vehicles cooperating with equipment intended for the monitoring of water spaces have a high potential for all kinds of exploratory work. An example of this can be USV equipped with the ROV (ROV – Remotely Underwater Vehicle). This System is designed for any underwater work on both sea and inland waters. However, there are few USV structural solutions designed to work with the ROV. Most often these are constructions specially designed for this purpose. An example may be an unmanned vehicle Yamaha UMV-H, presented in 2005, which serves as a platform for the unmanned underwater vehicle RDUST-VideoRay (Veers and Bertram, 2006) which are shown in Figure 2.

Figure 2.
Yamaha UMV-H and Video Ray Micro-ROV, (Source: Molchan, 2005).

The assumptions for the construction project of the Polish version of the Autonomous Surface Vehicle (ASV) were to develop and build a demonstrator of USV technology and later the ASV under the named "Edredon", performing tasks related to the perimetric protection of infrastructure critical in the framework of which (for the "Edredon" vehicle intended to be used for multivarianeous use by the possibility of equipping it with a variety of modules) is foreseen the use of an unmanned

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underwater vehicle type ROV operating on the USV deck. It was assumed that when decision on the need to perform a mission by an underwater vehicle is undertaken the autonomous mission carried out by the USV "Edredon" will be interrupted and the system will enter into the remote control mode, during which the operator located on a mobile land (or ship) command post will take the control over the ROV vehicle. The tasks of the operator at that time should be: the operation of the ROV from the unmanned underwater vehicle by means of a remote controlled launch and recovery system of the ROV (several concepts of such a system have been developed during the implementation of the project), execution of the set task, and then recovery of the ROV back on board of the USV "Edredon".

2. THE DESIGN OF THE LAUNCH AND RECOVERY SYSTEM OF THE ROV ON THE USV "EDREDON" BOARD

The use of such a solution due to the limited space on the stern of USV (Figure 3) turned out to be a very difficult task, that required the solution of a number of structural problems related to the operating conditions of the system, including but not limited to (Materials of projects, 2013):

- The risk of the cable line being screwed into the propeller, resulting from the significant submersion of the thruster;
- A limited platform surface to mount the launch and recovering system of an underwater vehicle on the USV deck;
- The way of mounting the system structure and taking into account the difference in altitude the surface of the water, imposing a segmented construction of the entire structure of the equipment for launching and raising of an underwater vehicle on board the surface vehicle;
- The need to use for the construction of light materials, which will not cause a large the vehicle's depth to the stern and the displacement of the metacentric height of the vehicle that would cause the of the swimming conditions as well as the performance of the USV;
- Limited possible construction height of the remote launching and recovery system of the vehicle does not cause an increase in the USV centre of gravity and thus manoeuvalability;
- Maximum offset of the system structure of the launching and recovery of the vehicle in the direction of the USV stern exposing the entire unit to continuous contact with water which imposes the use of seawater-resistant materials and equipment;
- The location of the platform on which the system is mounted must not restrict movement of the thruster, e.g. its trim;
- The platform must located above the thruster's elevation level, in its extreme top position.

One of the examined systems for launching/recovering from water of an unmanned type ROV underwater vehicle on board the USV "Edredon", is shown in Figure 3.

Figure 3.
Platform stern - the location of the launch and recovery system on the USV board (Source: Materials of projects).

An important problem that appeared during the design of the system became the choice of the appropriate ROV type submarine and equipping it with apparatus for the realization of tasks related to the perimetric protection of critical objects. As the underwater vehicle is intended to carry out underwater inspections in close proximity from the autonomous surface vehicle "Edredon", the technical assumptions are formulated based on an analysis of the possible tasks. Concerning the work of the ROV and its operational capacities such as: mass, dimensions, immersion, equipment in sensors, etc. For the design of the system, among others (materials of projects and Olejnik.A, 2012):

The possibility of fast launching and recovery on the board of USV "Edredon" (time of launching the garage with the ROV or the time of its lifting on board USV) should not exceed 60s.,

- The weight of the ROV in the air should not exceed 20 kg,
- The geometric dimensions should be in a rectangular wall with a volume of up to 1m^3,
- The vehicle should be capable of operating in the Baltic Sea environment at depths 50 m,
- The underwater vehicle should be equipped with sensors to detect contaminations chemical and biological
- The vehicle has the ability to determine its own position, e.g. for the purpose of determining the location of contamination,
- Detection and/or classification of underwater objects is possible.

However, the most important element was the transmission of images from cameras and sensors mounted on the ROV to the mobile land (or ship) command post and the ROV's remote control.

3. THE EQUIPMENT OF THE UNDERWATER VEHICLE IN SENSORS AND DEVICES EXTENDING THE OPERATING POSSIBILITIES OF THE VEHICLE.

Based on the analysis of the vehicles, available on the market, a underwater vehicle LBV200-4 type ROV of the American company Teledyne SeaBotix Company was selected (Figure 4).

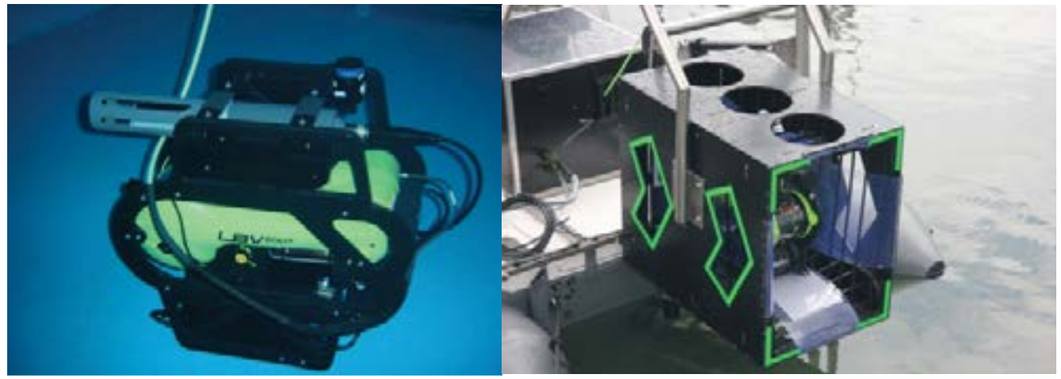

Figure 4.
Remote controlled underwater vehicle LBV200-4 mounted on the board of USV "Edredon" (Source: Materials of projects).

In order to ensure that the vehicle LBV200-4 is carried out under water under the hydrometeorological conditions, several additional sensors and devices extending the operating capabilities of the vehicle have been selected. Due to the possible use of the ROV vehicle to cooperate with the USV and to perform the widest possible spectrum of tasks, the vehicle was additionally equipped with [Materials of projects]:

- Rear camera supporting the operator with the launch and recovery system control,
- Manipulator robot with three-jaw gripper;
- Additional Outdoor Lighting
- BlueView sonar with a viewing angle of 130 °,
- Subwater Positioning System Tritech MicronNav USBL;
- Probe for measuring the physico-chemical parameters of marine pollution.

The task of the rear camera is to assist the operator of the ROV during the operation of its launching from and recovery on board the USV "Edredon" to prevent the misalignment of the cable line in the water and on the drum (Figure 5).

The three-jaw gripper-the (manipulator - Figure 5), in addition to the possibility of carrying out simple inspection work, ensures the transfer of objects found on the USV.

One of the tasks carried out by the unmanned surface vehicle "Edredon" is the detection of chemical and biological contamination. Therefore, the probe for measuring marine environment parameters is, from the point of realization of tasks set in the project, one of the most important components installed on the underwater vehicle. During the selection of the submarine LBV200-4 the attention was also paid to the possibility of equipping the vehicle with a water quality probe,

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Figure 5.
Rear camera of the ROV with annular backlighting, (Source: Materials of projects).

which is able to measure and send to the command center, via the "Edredona" wireless communication systems, a dozen water quality parameters. For the measurement of the physico-chemical contamination of the marine environment, the YSI type 6820 probe (Figure 6), which was integrated into the vehicle, was used to transmit the RS-232 serial link backup data.

The available sensor optical sensors detect and measu re the following components in the water:

- Dissolved oxygen;
- Blue-green algae;
- Chlorophyll;
- Water turbidity;
- Rodamine.

The following water parameters can also be measured using the 6820 sonde:

- Temperature;
- Conductivity;
- Salinity;
- Proper conductivity;
- PH, ORP, TDS ratios;
- Water flow;

The content of nitrate nitrogen, ammonia/ammonium nitrogen, chloride (ISE).

Figure 6.
Water quality sonde and manipulator of the ROV, (Source: http://www.ysi.com/products.php, http://www.seabotix.com/products/lbv200-4.htm).

The sonde transmits signals to the ROV Central Unit. The data from the sonde, as well as the sonar data and the underwater positioning system, are converted into an optical signal transmitted to the cable line drum. There, they are converted to an analog signal that is transmitted to the Central Control Unit of the ICC (Integrated Control Console) or a PC-class computer with built-in software to receive this data.

The unmanned surface vehicle "Edredon" with the LBV200-4 underwater vehicle is to perform various tasks in the Baltic Sea area, in particular the Gulf of Gdansk. Due to the poor visibility of the Baltic Sea water (ranging from 4 to 10 m, deteriorating as the depth increases) there is a need to install additional lighting on the vehicle. The project uses a set consisting of two LED heads, which gives the light flux of 2860 lumen (Figure 7) with the basic illumination.

Figure 7.
Additional Outdoor LED Lighting (Source: http://www.seabotix.com/products/lbv200-4.htm).

Another additional device is the sonar. The project decided to choose BlueView's high-performance 2D sonar with a viewing angle of 130 ° (Figure 8).

The sonar is placed at the bottom of the vehicle, on a specially prepared platform integrated with the backbone of the ROV vehicle. The sonar image is transmitted using RS-232 serial transmission. The transmission from the socket is converted to optical signals, so that they can be transmitted using a fibre optic cable to the converter located in the cable line drum. There, the optical signal is converted to the transmission with a twisted-pair computer cable and forwarded to the ICC (Integrate Control Console).

Figure 8.
Sonar 2D Blueview P900 (Source: https://www.ashteadtechnology.com/product/teledyne-blueview-p900-130-2d-forward-looking-imaging-sonar).

The underwater positioning system is an important device for increasing the ability to operate the underwater vehicle. It allows to determine the position of the underwater vehicle in regard to the surface vehicle, record the trajectory of its movement, and determine the position of possible objects, e.g. Possible sources of chemical and biological contamination. SeaBotix offers positioning System Tritech International MicronNav (Figure 9). The System has a range of 500 m, positioning accuracy ± 0.2 m and bearing accuracy ± 3°. The positioning speed is from 0.5 to 10 s. This System consists of:

- MicronNav interface,
- USBL Transducer,
- MicronNav Underwater unit.

Figure 9.
Underwater Positioning System Tritech International MicronNav (Source: Materials of projects).

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4. CONCLUSSIONS

Based on the accepted tactics of the vehicle use, and its measured real dimensions and weights, as well as the specified possible locations for the positioning and fastening of the elements of the launching system on board of the unmanned USV vehicle, the choice of the way of launching of the ROV was made (3 concepts were developed – preliminary projects for launching and recovering of the ROV on board of the USV "Edredon") (Materials of projects, 2013), the positioning of the launching system, and the location of the transducer for underwater navigation. It was assumed that the ROV will be transported on the board, and then lowered, and recovered from the water in a container, the so-called underwater garage. The vehicle should not be able to move when it enters (retracting) the garage, and the garage itself should be a construction that protects the ROV from mechanical damage during transport to the area of operation and at the time of leaving and particularly in the surface wave impact zone.

Trials and tests of the launching system of a ROV-type submarine, under laboratory and real-life conditions, have demonstrated its correct operation. It turned out, however, that the designed construction of the ROV garage is too heavy for the tested surface vehicle "Edredon. The ROV operator was advised to observe the reciprocal positioning of the vehicle and the garage with a rear-view camera mounted on the ROV when manoeuvring the vehicle for its garages after the mission was performed, and on the basis of these observations corrected the operation of the winch cable line vehicle. The study also verified the interoperability of the system mechanisms with the USV platform design and a cant test. The results of the cant test confirmed the design assumptions given to the launching system and its minor influence on the stability of the "Edredon" USV unit after its installation on board (Materials of projects, 2013)].

The construction of the garage requires further work related to reducing its weight e.g. by changing the applied construction materials.

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How to Avoid Mistakes in Software Development for Unmanned Vehicles

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The purpose of this paper is to propose a design and development methodology in terms of robustness of unmanned vehicle (UV) software development, which minimizes the risk of software failure in both experimental and final solutions. The most common dangers in UV software development were determined, classified, and analyzed based on literature studies and the authors' own experience in software development and analysis of open-source code. As a conclusion, "good practices" and failure countermeasures are proposed.

KEY WORDS

~ Unmanned vehicle
~ UV
~ UAV
~ Software development
~ Software robustness

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1. PROBLEM IDENTIFICATION

Software for application in the unmanned vehicles (UV) is usually developed not by professional Functional Safety (FuSa) developers, but rather by people coming from other technical backgrounds related to the currently developed unmanned vehicles. One of the authors of this paper represents such an example, and the other one has a formal educational background in software development. The cases described here and their analyses allowed the authors to formulate some conclusions and directions on how to avoid mistakes in software development for unmanned vehicles' initial tests and how to make their further development smoother. This paper will not cover FuSa certification process guidance, such as a formal Hazard and Risk Analysis (HARA), but rather contains good practices for persons who e.g. want to test their new sensing or control algorithm safely. The discovered roots of failure can in most cases be avoided by using simple workflow rules and good programming practices. They can be defined and then easily incorporated by developers to increase robustness of the software and to eliminate or at least to minimize the chance of the developed vehicle's failure. The design rules presented here increase operational safety in the process of UV prototyping. Sharing them with less experienced programmers will have a positive impact on the quality of the final software. The awareness of risks related to UV software may also guide senior developers/software architects to apply the presented countermeasures in their projects, even at the expense of increased costs, time, software licensing, and similar.

The authors utilized their expertise in aeronautics in general, and in unmanned aerial vehicles' (UAV) software development in particular. Many of UAV software developers originate from open-

source projects. Applying the rules described below into these projects will have a significant impact on the hobbyists' work, who will benefit from increased reliability of their constructions. It may also be profitable for researchers, in whose case a smooth integration of experimental modules will simplify the prototype development process and increase the scientific progress of knowledge on UVs. This paper transfers "good practices" in software development into a compendium, which will help to increase software quality in UV research.

The terms of software development for UAV applications can be easily compared to the respective rules for manned aircraft. The main factor to be taken into consideration during the development of man piloted aviation software is the safety of the aircraft operation. For a UAV, one can formulate that the main factor is either a quick and cheap software development if the standard, open-source software cannot be applied, or free software available for that purpose to be adopted to the specific requirements of the developed project of a new or modernized UAV.

Software development on micro- and mini-class UAVs, which are the most popular among the users being also software developers, is not restricted by any standard. In contradiction to software for full-size aircraft, developers are not limited by certification requirements and standards, such as DO-178. From the researchers' point of view, this situation is highly beneficial as the whole development process can be drastically shortened. The lack of significant limitations enables them to use state-of-the-art solutions in terms of languages, coding techniques, software development tools, etc. The development of a new human-crewed aircraft, even using modern tools and processes, often takes more than ten years – mostly due to extensive certification and development procedure requirements. In terms of modern software development during such an extended period, almost all modern solutions often became obsolete.

Let us consider part of the newest standard (relative to 20/04/2019) for aviation software development, DO-332, which is a supplement to DO-178C and DO-278A. All these documents were introduced in 2011. DO-332 provides evaluation and acceptance criteria for Object-Oriented Programming (OOP) dedicated to aviation. The idea of OOP began to develop in the 1960s. The current "golden standard" for OOP embedded programming – C++ language – has been introduced in 1983, and nowadays compilers even support it for microcontrollers, such as ARM Cortex. Since 2011, three major standard revisions, C++11(ISO/IEC 14882:2011), C++14(ISO/IEC 14882:2014) and C++17(ISO/IEC 14882:2017) were published, but still will soon be replaced by already announced C++20.

As long as standards such as DO-178C do not forbid modern software development techniques such as Test-Driven Development (TDD) to be used alongside the formal, certified ones, the accepted techniques and tools may still not cover many useful features and capabilities of modern languages. This situation makes mentioned small UAVs to be excellent prototyping platforms for aviation software of the future.

Unfortunately, such lack of formal guidance in aviation may cause major hazards. All the procedures related to aviation software development are focused on safety. A small UAV may not cause such danger as an airliner. Nonetheless, the failure of onboard systems may still cause severe damages not only to the platform itself but also to people and objects around it. That is becoming even more important as the UAVs are being widely used not only by amateurs, but also by professional operators for many purposes, e.g. power grid screening, precision agriculture, picture and footage of private and mass events, cargo deliveries and many others. All the expanding areas of UAV applications are either visual line of sight (VLOS) or beyond visual line of sight (BVLOS) operations. Particularly the last mentioned type of operation could be seriously impacted by immature and not entirely safe software.

In the authors' professional career we heard statements such as "We crashed X prototypes – so our software is in an advanced state", or "Searching on an analytical solution, e.g. PID, is the domain of scientists and not "real engineers" who make money on their projects." In order to understand what is inherently wrong in such an approach, let us imagine that such words came out of your car tire design engineer. Would you entrust the life of your family in such a design attitude during a highway vacation trip?

The main goal of this article is to show that even for prototypes there is room for safety and robustness. Even when full, formal HARA is not required, it is worth remembering safety and some basic precautions leading to achieving it. We summarize below with explanations and comments what in our opinion are the most important ones. However, let us first remain with the end to which simple bugs might lead.

2. BRIEF LESSONS FROM THE HISTORY

In aviation software development, it is always worth remembering that even the smallest bug may cause a serious hazard. Those situations even happened in the most rigorous software development environments such as space missions or healthcare devices. The following list will briefly introduce a few examples which are considered the most tragic software failures in the history of software development.

(1) Atomic Energy of Canada Limited Therac-25

One of the most tragic software failures happened in Therac-25, produced by Atomic Energy of Canada Limited and used in medical examining. Those x-ray machines caused the death of at least six patients due to beta-radiation lethal overdose. The device had two modes of operation: weak electron beam and x-rays scanning. The latter utilized a high-energy electron beam which was converted to the x-ray radiation within safety limits by a collimator and an ion chamber. Due to a faulty retraction of a conversion module in an x-ray modem caused by the software, patients were exposed to a high level of beta radiation, which caused severe damage to their bodies.

From the software side, this failure was caused by many factors and flaws in the design and implementation procedures. Reports from the investigation (Leveson et. al., 1993) show that many development process flaws, such as controlling a module position in an open-loop configuration (without a position detection), race conditions in software during fast keyboard typing in the control panel, a flag incrementation and lack of a proper review process during software development were present.

Conclusion: Poor software quality and pursuit of deadlines instead of quality might lead to fatal injuries.

(2) Mars Climate Orbiter

One of the critical sections of the software is its API. Simple errors such as unit mismatching may lead to tragic events. Such a case occurred in NASA's Mars Climate Orbiter project (Mars Climate Orbiter Mission Homepage, 2000). In the main specification of the project, the SI unit system was defined as the unit standard. Unfortunately, the part of the Martian ground approaching software delivered by an external contractor Lockheed Martin interpreted the specific impulse value as a $\frac{lbf}{s}$ instead of the specified $\frac{N}{s}$, which caused an error by factor ~4.5. The problem had not been detected before the mission launch and manifested itself during the Mars orbit insertion maneuver. A guidance system was designed to lead the spacecraft into the orbit 160 km above the Mars ground level in order to perform aerobraking. During this maneuver, the vehicle wrongly descended to 57 km, where atmospheric friction caused its overheating and destruction. The flight controllers in the Mission Control Centre spotted the deviation of the orbit and proposed to perform a Trajectory Correction Maneuver No. 5, but in the end the correction was not applied.

Conclusion: Mars Climate Orbiter mission, whose costs were estimated to $328 million, failed due to a simple failure to correct unit conversion error.

(3) Ariane 5

Another conversion error caused the failure of Flight 501, performed by Ariane 5 launcher (Lions, 1996). It led to the triggering of self-destruction sequence ~40 s after launch. The problem occurred in a layer of integration between the new and reused software already tested in filed subsystems coming from Ariane 4. One of the critical navigational values was calculated as a 64-bit floating-point and then converted to a 16-bit integer due to compatibility requirements. Unfortunately, the new, more powerful launcher design caused the value to overflow, which triggered operand error. That small error combined with unfortunate circumstances caused the catastrophic failure whose cost was estimated to $7 billion.

Conclusion: Lack of integration testing on the "proven in use" component cost $7 billion.

(4) the author's experience

Such errors may also occur for small UAVs. They are less expensive, but still may cause harmful situations for the operators and the environment. One of them happened to one of the authors during the research of the AHRS system for one of the projects. In order to implement a new AHRS subsystem, he had to prepare a new multirotor for flight. One of the steps of the setup procedure was a pre-flight PID tuning on a harness. The Ground Station (GS) software had managed all the regulators. Unfortunately, one of the programmers delivered hardcoded mode switch for experimental autonomous navigation system into the central repository, not passing the information on it to the other researchers. This small piece of code contained overwriting of the main flight mode settings and caused misconfiguration of PID controllers on the tuned vehicle. During a routine tune procedure, the vehicle fell into uncontrolled oscillations, which shortly led to an unexpected full-throttle command for one of the engines. A brushless motor, with 1,000 KV RPM constant at full speed combined with a 4s Li-Po battery and the 10-inch propeller may cause severe injuries. Fortunately, in our case it left only a code quality remainder in the form of a scar on one of the author's hands.

Conclusion: A temporary solution and lack of proper communication almost caused the author to lose his precious fingers.

3. GOOD PRACTICES IN SOFTWARE DEVELOPMENT

Remembering the above described cases and taking into consideration the UV software development conditions and priorities, the authors tried to formulate in a possibly clear way some advice for non-professional software developers. Also, professionals can apply some suggestions for their projects' performance.

(1) Write a developer-friendly code

Rule No. 1: Do not write software in a crypto style. Make it clear for any developer, even for yourself.

A valid code means, in principle, the code understandable to a machine. In order to make software development efficient, it also has to be understandable to a human. Modern compilers are very efficient in the optimization of assembly code. They are often considered as even superior to an experienced assembly programmer in terms of code performance.

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Let us introduce an example: many language features, which were designed to enable low-level programmer manipulation, are currently obsolete. The keyword "register", which suggested old C compilers to keep a variable in the CPU register for easy and fast processing, is ignored by most modern compilers. Even authors of programming books do not include it in their new C language tutorials. Python developers also decided not to implement incrementing and decrementing operators, which were iconic for previous generations of programming languages. Iterable objects and language-specific inline loop operations replaced them.

Modern programmers are not as restricted in terms of writing machine-optimized code as they were a few years ago. They are permitted to write better quality, self-documenting code, which is oriented to ease of workout instead of performance optimization.

There comes one advice which came from the authors' experience: write your software in a way that even a 9-year-old child with the basic knowledge of programming could understand. If you have a part of a code which requires much effort to understand and to make it work – write a comment about the details.

Additional lines of information will not affect the code size nor performance, but will significantly save investigation effort of other programmers or even of the original author when some changes are required. A few additional minutes spent on writing them is a small fee to pay. Moreover, to write a sufficient comment, you have to understand the root cause of the problem and express it, which may protect you from accidental programming. It will also focus other programmers' attention on a problem – during e.g., reviewing process – which may trigger a discussion about refactoring lower levels of the software in order to avoid fighting the same problems over and over again.

It is also advisable not to use uncommon and sophisticated language constructs, especially if they do not bring any added value in terms of code size, performance, or improved readability. Usually, there is a good reason why even experts in a particular language do not use it. Often, the amount of time that would have to be consumed to understand and verify the correctness by the programmer who will work on this code in the future is unacceptable, and as a result, such sophisticated coding does not bring any added value to the project.

It is also beneficial not to forget about the underlying programming rules, such as a descriptive naming or separating code blocks by inline functions and comments with information about optimizations, tested solutions, and design decisions. The code written according to these rules will benefit from fewer bugs, due to simplicity. It leads us directly to the second rule of this guide.

(2) KISS

Rule No. 2: Do not complicate software in its structure or functionalities. Simple is beautiful and practical.

Acronym KISS is usually expanded as "Keep It Simple, Silly." It is often combined with another rule: "You Aren't Gonna Need It". Programming languages usually offer many ways to solve a particular problem. The above rule tells that the most straightforward way is almost always the best one. An overcomplicated structure and unnecessarily complex mechanisms not only makes software development harder, but also creates more opportunities for making a mistake. It is recommended to use complicated structures only when it is necessary in order to fulfil the requirements. Over-engineering often leads to performance drop, an increase in maintenance effort, and overall bug quantity in a code.

Usually, it is also beneficial not to implement functionalities in advance. It may cause an unnecessary increase in software's size, and it often leads to dead and untested code. If such an additional feature is required, a more intuitive and efficient way to implement it may be applied.

There is a good example of the authors' experience, which illustrates problems with the complexity of the software (Szczepański, 1987). The task was the following: write a parser of guidance commands for a combat navigation simulator in the Fortran. Each command could include several flight parameters and had to be parsed and executed in a single unit of simulation time. Back then, Fortran supported neither Object-Oriented Programming (OOP), nor sufficient abstraction layer to provide a generic solution for parsing such commands. The code was simple in principle, but the software fabric, which connected particular fields in command with flight parameters was so complex that it required more than ten pages of documentation and training on how to use it. Even after a few months after release, trivial errors such as wrong interpretation of a parameter were present in the code. In that case, complexity was enforced by the programming language limitations, but even nowadays, with all of the mechanisms such as polymorphism or template programming, such an inefficient and complex approach appears in the software from time to time.

(3) DRY

Rule No. 3: Do not apply the "copy and paste" technique during software development. It takes more time to correct it.

Another great practice is "do not repeat yourself." If there is a fragment of code which shares a similar structure or function, it is always a good idea not to copy it all over the software. Instead, such functions should be generalized or included in a common section and applied to a specific part of the software package.

Let us imagine two independent accelerometer-based subsystems. One of them is detecting acceleration for IMU/AHRS system, and the other one is a collision detector. If the accelerometers are of the same type, they might share configuration routines which will be then parametrized. You may need additional testing coverage for this procedure, but ultimately you do not have to write and test the same thing twice. In addition, you can reuse these routines in other projects or implementations. You may need only minor adjustments to make it work.

In the same way we can think about digital filtering or mathematics primitives such as matrix or quaternion multiplication. Such implementation may need a more extensive testing than straightforward implementation, but the time and robustness gained make it highly profitable in the long run.

It may positively impact not only the code size, but it also makes debugging and bug fixing easier. If one finds a bug in the common section, a single patch will fix it for every usage of that procedure in the software. This approach will also lead to more generic solutions, which will simplify the further development process.

From FuSa's perspective, such an approach has its drawbacks. Shared code must be compliant to the highest safety standard in which it is used. On the other hand, when you have e.g., a SIL-4 certified matrix multiplication library in use and something is not working, you will focus on the implementation details. At last, you will look for a bug in the library, as the SIL-4 is the highest level according to IEC 61508 standard.

(4) Scout rule

Rule No. 4: Do not keep unclear parts of the previously developed software. Clarify them when discovered and do not procrastinate this work.

One of the scout rules is to leave a camping place in a better condition than found at arrival. The same rule can be applied with common sense to software development. Here is an example. Every project has its coding style which has been specified by previous developers. Some of them are defined, such as K&R or GNU, but usually they are applied with slight modifications according to a developer's preferences. From a workflow perspective, not a particular style, but its consistency is a crucial factor. All style derogations force developers to make an additional effort to analyze and understand the code, which may significantly elongate even the simplest task.

In order to make a project pleasant to work on, it is always profitable to correct style flaws according to a commonly agreed standard. Small mistakes, such as typos, bad grammar in comments, or too long lines are also worth fixing at the moment when they are noticed. More significant errors usually have to be reported and dealt with accordingly. If something has got your attention, e.g. a lousy style habit, it is a good practice to ask co-developers about the reason why it has been applied. There is a big chance that they share the same opinion about it, and it has to be corrected in order to improve the code quality for further comfort of development.

(5) Modularity

Rule No. 5: Do not perform all functionalities in a one-stop-shop.

Divide an elephant into elementary pieces and make them work as one creature. Then you can easily change that creature's elements.

Flight control is usually a complicated and an entangled piece of software where applying the "divide and conquer" rule makes the development much more manageable. Keeping functionalities in a small (KISS) and functional oriented modules/layers gives more flexibility, makes the code easier to manage, solves repetitive naming issues, and helps to avoid unnecessary feedback.

Many early implementations of autopilot software suffered from a lack of separation between components, i.e. code responsible for communication was interleaved by processing, filtration, and compensation routines. It often caused difficulties with expanding functionality or finding a bug.

A much more efficient approach is to design modules and track interactions between them. In such structured software, the change in one part of the software should not affect the others. Modification of Hardware Abstraction Layer (HAL) will allow for e.g. transmission protocol change improved transfer efficiency by DMA or support of new autopilot hardware. By modifying raw data in the measurement routine, higher accuracy sensor support can be easily added. Significant changes, such as airframe type, may also require only a reassembly of the already present control modules and redesign of signal mixers. Such capabilities allowed e.g. Pixhawk or Ardupilot auto-piloting software to support many airframes and hardware vendors on a variety of platforms – from bare-metal microcontrollers (MCU) up to Linux-driven computers with features like cameras, Wi-Fi modules and similar.

One of the projects, which one of the authors participated in, was terminated due to a lack of sufficient API separation between the modules. The software was developed on Cortex-M3 MCU, without the Floating-Point Unit (FPU). On-board software used state-of-the-art solutions in terms of Digital Signal Processing (DSP) and navigation. Unfortunately, cost related to implementing floating-point operations became too high. It enforced the reduction of main loop frequency, which led to problems with stability margins.

Due to the complex nature of software, the author was

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unable to port the whole software to MCU with FPU easily. A decision was made that only navigational and DSP parts will be moved to the Cortex-M4 processor on a dedicated extension board. One of the significant problems, which occurred afterwards was related to the program's structure. Separation of AHRS and navigation module required major changes in almost all the routines in Autopilot and Ground Station due to, among other things, complex calibration procedures.

(6) Defined APIs

Rule No. 6: Do not write an API without its precise specification before starting coding activity.

Good module separation cannot be achieved without a proper API specification. Multiple signals and data processing streams are crucial parts of the flight controller. If each component had a well-defined task, inputs, outputs, and functionality, this would significantly increase clarity of the system operation. Similar data streams can also be aggregated into a bus, which may be handled by e.g. a dedicated structure, enabling signal dependency tracking and simplifying a logging and telemetry transmission.

Ignoring such recommendations may lead to errors such as using raw instead of filtered data, creating unintentional loops in adaptation algorithms, or creating unnecessary cross-dependencies between software components, which may lead to problems with portability and multiplatform support.

(7) Recovery handling

Rule No. 7: Do not think that recovery of your software failure will never happen.

Plan recovery processes of the software failure most effectively and safely, even for the cases which cannot occur.

As Arianne 5 example has shown, in the control software all of the errors, even unexpected, should be handled safely. In FuSa terms, such behavior is called "failing gracefully" and is required or highly desired. The typical situation implies a fast recovery to the fully operational state. Usually, the "safe side" failure solutions are also acceptable. This goal may be achieved by exception handling, simplified backup algorithms, or data integrity checks. All unhandled erratic behaviors are potential points of failure, even if they are not supposed to occur in proper program execution.

Rule No. 8: Use safety features embedded in your platform — track status of execution.

Most modern environments have embedded safety mechanisms such as assertions, watchdogs. For some people, the time used for proper configuring them may seem like a waste of time. Do not be one of them! Let us imagine that you are developing e.g. a motor controller. In the safe implementation, you can monitor if control data is received in given intervals. What might happen if you do not have such a solution and communication cable will disconnect when the powerful engine is spinning e.g. a massive propeller at full throttle?

Such solutions are called using the Japanese term "poka-yoke", which means "error proofing." If you can improve safety using a build-in procedure, it is the most convenient way to do so. You meet them daily. Did you think of why in ATM you receive your credit card back before the money is given to you? There is one main reason. When you go to ATM, you are focused on the goal – getting the money. Forcing you to grab your card before getting money helps you not to forget a card.

In software development, it may have many flavors. You can assert that if the given data is valid, you can track the state of the data and order of procedure execution. It is also good to think about what purpose your implementation will be used for. You can then find the things that people forget or do wrong, and care about their safety even without their noticing it.

(8) Tests

Rule No 9: Do not think your software is ideal.

It needs extensive testing, starting from the simplest basic units of your code.

The industry standard of software development often embeds the Test-Driven Development (TDD) technique for tracking and avoidance of software bugs. The main reason for that is related to significantly lower costs in terms of time and effort to patch a bug at an earliest stage of its development. Finding a bug embedded into a code which has many software layers below and was written a long time ago is highly inefficient. It consumes much time to investigate the source of the error or may require contacting the original author.

A variety of tests preventing the situations mentioned above are defined. In order to verify correctness, acceptance criteria, and properties of a small piece of a coding unit may be applied to the performance tests. Integration and functional tests can be used to validate the cooperation of components in the final solution, which can then be verified against the requirements by the acceptance tests in a real environment using e.g. the Hardware-in-a-loop (HIL) technique.

In complex systems, changes embedded into one module may cause erratic behavior in another seemingly unconnected component. The leading cause of such errors is usually tough to track. In order to detect them early, periodical regression tests are desired.

Coverage and static analysis tests can also test the proper execution of the code. They can detect other types of hard to find bugs such as invalid conditions, variable overflow, or a dead piece of the code.

One of the benefits of extensive testing is enabling developers to apply one of the Extreme Programming rules: "Fail it until you make it." It is especially desired for complicated and hard to develop pieces of code. It can also assure a proper design of the recovery handling procedures.

(9) Four eyes principle

Rule No. 10: Do not think you are a perfect software developer.

Share your ideas and code with others. They can see what is unfeasible to be seen by you.

"Four eyes principle" is a crucial element of many modern, agile programming and management techniques. It implies that at least two people should make any significant decision. It helps to avoid errors caused by subjective bias. This useful rule can also be embedded in a software development process as a review requirement. A review process enables other developers from the team to share their thoughts and comments about the code changes before they are delivered into the mainline of software under development. If the team and the software architect accept the proposed changes, they are embedded into the common base for further development.

Such an approach not only improves error avoidance, but also allows development uniformity and consistent coding style across the entire project.

(10) Proper use of development tools

Rule No. 11: Do not mix the tested and reliable parts of software with the newly developed if the latter have not been appropriately checked.

Modern development support tools enable developers to ensure safe cooperation on their software. However, there are two significant aspects to be aware of, which cannot be ensured by even the most advanced solutions.

One of them is to keep experimental, untested code in separate branches as long as they are not ready to be embedded into the final solution. Hacks and temporal functional overwrites are often required during the addition of a new, sophisticated functional update. One of the most important things is not to forget about keeping them tagged and separate from the mainline of the development branch. Not only does it allow other developers to work on the functionalities separately, but it also ensures the safety of operation, e.g. during flight tests which use experimental software.

The other, no less important aspect is to track temporary workarounds and not yet implemented functionalities. Time pressure on software developers is usually significant. It often leads to forgetting about things which need to be done. Putting a "to do" comment in code or an issue in the task tracker may prevent situations when the solution only seems to be ready for delivery while being left unfinished.

(11) Take your time

Rule No. 12: Do not be in a hurry when writing software.

You need to prepare healthy slow food which supports the vehicle.

Getting things right is far more important than doing them fast, especially in the development of software for flying objects. A danger of causing personnel injuries or crashing UAV on a car or a building is always a worse option than facing consequences of delivery after the deadline.

4. SUMMARY

The proposed solutions and methods are just the tip of an iceberg in terms of FuSa and safe software development for UVs. Many experienced developers may find the presented guidance being only truisms, but neither of them, we hope, will disagree with the importance of the presented aspects nor will deny the existence of failures caused by ignoring the above mentioned rules. As long as failures caused by improper development techniques happen, there is a need for a public debate on the robustness of unmanned vehicles software. The number of crashed prototypes should not be the measurement of vehicle motion control advancement. Recent improvements in a code quality of the popular open-source flight controllers dedicated to UAVs, such as ArduPilot (ArduPilot Code repository, 2017), LibrePilot (LibrePilot Code repository, 2017) or Pixhawk (Pixhawk Code repository, 2017), have shown that the need begins to be noticed. All UV software programmers share the same goal: to make software as failure resistant as possible. It is the required step for breakthroughs in aviation of the future, such as autonomous flights over urban areas in the so-called U-space. Software already started to follow this path, but there is still much work to do. The same problems are connected with other types of UVs. They are not so broadly and loudly discussed as they are mostly being developed for professional applications, often military, or for use in unpopulated areas. In such cases, the development cost factors prevail the safety reasons.

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Port Area of the Split Port Authority in the Function of Economic Development: Concessionaires Attitudes

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Measures needed to be implemented by the Port Authority at the maritime domain of the Port of Split in order to strengthen maritime traffic and stimulate economic development of the city were examined by conducting the structured questionnaire among concessionaires in the port area. The collected data were processed using the Friedman test and Sign test. Among six options, the concessionaires mostly indicated variable of building an infrastructure that will promote and attract the presence of different forms of maritime traffic in the port as the best choice for the initial purpose. Different forms of maritime traffic enable more business opportunities to compensate for the potential operating loss in case of declining maritime traffic. The Port Authority should consider the concessionaires' attitude, despite the possibility to express their own business interests within, as their business results are closely related to the size of maritime traffic in the port.

KEY WORDS
~ Maritime traffic
~ Economic development
~ Port authority
~ Port of Split
~ Concessionaires

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1. SPLIT-DALMATIA COUNTY IN THE FUNCTION OF THE MARITIME ECONOMY

The Split-Dalmatia County is the fifth most developed county in the Adriatic region. Regarding the level of development, it is moderately developed county in Croatia. The economic growth of the County is of utmost importance, from the aspect of promoting the maritime economy, especially regarding the County's ability to invest in transport infrastructure (Split – Dalmatia County, 2017). Investment activities, available knowledge and skills in the form of human resources and motivating (local) economic policy are part of the factors that ensure the economic growth of a particular region (counties), where this growth is reflected in the ability of a certain region to invest in a transport infrastructure serving the economy. Developed transport infrastructure is a prerequisite for economic growth, and vice versa (New Zealand Government, 2016). The County's traffic network represents a network of traffic connections that connect the County centers with other economic centers in hinterland and foreland of the County. Considering the maritime transport, the County traffic network consists of following activities:

- regular passenger transport service lines between two or more ports inside the County and/or adjacent counties. Most of these are fast – shipping routes connecting the ports situated mostly on islands, in centers of island settlements. As the number of inhabitants on islands increases, the demand for such a type of transport is also expected to grow, especially as such transportation will become a complement to Ro-Ro passenger ferries;
- Ro-Ro passenger service lines which are natural continuation of road traffic and therefore, organized according to

the requirements of road traffic. These services strongly depend on the economic development of a single island. It is objective to expect an increase in this type of transport, but still to a lesser extent than the expected development of regular passenger service lines;

- intermittent freight traffic to individual destinations, which includes the transport of small amounts of cargo by smaller vessels to remote island centers (Faculty of Maritime Studies Rijeka, 2010).

2. CURRENT SUPPLY AND DEMAND OF MARITIME SERVICES IN THE SPLIT – DALMATIA COUNTY

The port infrastructure in the County consists of six industrial ports, ten ports of nautical tourism (eight county and two state – owned), 65 open ports for public transport (39 local, 20 county and six international), 49 sport – recreational ports (of County significance), eight piers (five counties and three state – owned), four shipyards (two county and two state-owned) and one service base.

There are a total of 15 public maritime shipping line services in the County having public procurement obligations including eight ferry lines, six fast bout catamaran lines and one classical ship line. There are also six lines without a public service obligation (CLSA, 2017).

It can be stated that the port system forms several subsystems connected to the port network, intending to connect all subjects at the national level. The development of a port within such system affects the development of the overall economy, and vice versa. That is why the development and design of the port system is a matter of national interest. The establishment of port authorities in the Republic of Croatia is one of the measures to create the economic and legal basis for the development of the national port system and the individual ports within that system, regardless of whether the port has state or county significance (Jugović et al., 2009).

3. PORT AUTHORITY OF SPLIT-DALMATIA COUNTY AND THE SPLIT PORT AUTHORITY

The significance of maritime transport for the economic development of counties in the Republic of Croatia in general, and particularly in the Split – Dalmatia County, is visible in concrete terms within the applicable legal regulations. Namely, by the Maritime Law and Seaports Act (Croatian Parliament, 2009), counties are entitled to establish county port authorities with the aim to contribute to maritime development, and main overall objective of improved management of maritime affairs in their area.

Ports open to public traffic are classified according to the size and importance as of:

- economic interest for the Republic of Croatia,
- county's significance,
- local importance.

The founder of the port authority for the ports of special international economic interest of the Republic of Croatia is the Government of the Republic of Croatia, and the county's assembly for the county level ports. Six port authorities open to public transport have been established in Croatia having particular (international) economic interest. These are the ports of Rijeka and Ploče, principally intended for freight traffic, and the ports of Zadar, Split, Šibenik and Dubrovnik having primarily activity of passenger traffic. Based on the decision to establish the port authority, a port area is defined, i.e. the maritime domain over which the port authority's competence spreads. Port activities along with infrastructure and superstructure facilities are also established, and relevant by-laws are adopted, thus creating a legal framework for the development of the national port system and certain ports within it (Batur, 2010).

Accordingly, on March 1st, 1999, the Port Authority of the Split – Dalmatia County was founded based on the Maritime Domain and Seaports Act and the Split – Dalmatia County Statute. The purpose of its founding is to manage, build and utilize ports open for public traffic of county and local importance.

The Split – Dalmatia County Port Authority's activities are as follows:

- concern for the construction, maintenance, management, protection and improvement of the maritime domain that represents the port area,
- construction and maintenance of the port infrastructure, financed from the budget of the founder of the port authority,
- expert supervision over the construction, maintenance, management and protection of the port area (port infrastructure and superstructure),
- ensuring permanent and uninterrupted performance of port traffic, technical-technological unity and navigation safety,
- ensuring the provision of services of general interest or for which there is no economic interest of other economic entities,
- harmonization and supervision of the operation of concessionaires performing economic activities in the port area,
- making decisions to establish and operate a free zone in the port area and regulate free zone and other activities by the Law (Port Authority of Split – Dalmatia County, 2017).

By the founding of the Split Port Authority, in sense of investment in port infrastructure and superstructure, the most prosperous period of the Split – Dalmatia County has taken place. This trend has resulted in significant maritime development. It is determined by improved connection of the coastal area with the islands of the Split – Dalmatia County, as new ports are being built and existing ones are being expanded, thus creating preconditions to accommodate more advanced and larger vessels. Furthermore, the development of maritime activities in the area of Split – Dalmatia County is particularly evident in the development of nautical tourism activities, which have had remarkable economic indicators in recent years. To conclude, the development of maritime traffic in the area of Split – Dalmatia County is extremely important, especially if viewed in the context of improvement of quality of life on islands (Split Port Authority, 2017).

4. MATERIAL AND METHOD

Confirming the above mentioned data, that maritime traffic in a particular port area under the management of a particular port authority undoubtedly contributes to economic development, the aim of this research is to investigate what needs to be done at the maritime domain under the management of the Split Port Authority in order to stimulate greater economic development of the city. The research is based on the perception of economic entities (concessionaires) at the maritime domain of the Split Port Authority concerning the state and perspectives of maritime transport in the Port of Split.

A structured questionnaire was used in the research, conducted for this paper, as a data collection method. With the use of questionnaire, the attitudes of concessionaires carrying out economic activities were collected in the port area of Split. The survey was conducted in the city of Split in October 2017 using the online Google Docs program. All concessionaires operating in the port area of Split were requested to participate in the research. It is important to emphasize that economic activity in the port area can only take place through a concession. There were 80 concessionaires engaged in maritime and allied activities in the port area of the city of Split at the time of conducting the research. The questionnaire was sent to all 80 addresses. The questionnaire was filled in by 23 respondents, i.e., 28 % respectively. Although the response rate was low, it is important to note that among the respondents who responded entirely to this questionnaire were concessionaires who carried out 80 % of the economic activities in the Port of Split and therefore, the survey results can be considered representative.

Through the questions, six (6) variables (v1 – v6) were offered to the concessionaires to assess at what extent each of them, in their opinion, could contribute to the better economic development of the city of Split. The variables are shown in Table 1.

Table 1.
Variables of the conducted research.

Invest in optimizing a superstructure that has so far not been appealing to economic entities	v1
Build an infrastructure that would better connect the port with its gravitational area	v2
Establish an integrated port IT system	v3
Build infrastructure that will encourage and attract the presence of different forms of maritime traffic	v4
Enter a maritime domain, that is not included, in the land register	v5
Define port tariffs (dues and fees) according to the competition in the surrounding area	v6

The questions offered the answers with Likert's one – to–five– scale estimating (Šundalić and Pavić, 2013) as follows:

- 1 – irrelevant;
- 2 – not relevant;
- 3 – neither important nor irrelevant;
- 4 – important
- 5 – completely important.

The data collected in survey were analyzed with the use of statistical programs IBM SPSS Statistics and MS Excel. The significance of data was controlled by descriptive statistics (Burić, 2018) and nonparametric statistical assays as Friedman's chi-squared test (Charles Zaiontz, 2017) and Sign Test (Shier, 2004).

5. RESULTS

The results of the research are shown in Table 2 based on the scoring principle of Likert scale (1, 2, 3, 4, and 5). The most acceptable answer on the questionnaires scale of importance, of what should be done on the maritime domain of the Port of Split in order to stimulate greater economic development, refers to the variable v4 (Build infrastructure that will encourage and attract the presence of different forms of maritime traffic), which was accepted by 87 % of the respondents, and 52.2 % of respondents consider this variable to be of utmost importance.

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Table 2.
Activities to be undertaken on the maritime domain of the Port of Split to boost greater economic development.

What should be done on the maritime domain of the port area of the Port of Split to encourage greater economic development?	Irrelevant (1)	Not relevant (2)	Neither important nor irrelevant (3)	Important (4)	Completely important (5)	No answer
Invest in optimizing a superstructure that has so far not been appealing to economic entities (v1)	1 (4.3 %)	2 (8.7 %)	5 (21.7 %)	6 (26.1 %)	8 (34.8 %)	1 (4.3 %)
Build an infrastructure that would better connect the port with its gravitational area (v2)	0 (0.0 %)	4 (17.4 %)	1 (4.3 %)	9 (39.1 %)	8 (34.8 %)	1 (4.3 %)
Establish an integrated port IT system (v3)	3 (13.0 %)	3 (13.0 %)	2 (8.7 %)	4 (17.4 %)	9 (39.1 %)	2 (8.7 %)
Build infrastructure that will encourage and attract the presence of different forms of maritime traffic (v4)	0 (0.0 %)	1 (4.3 %)	1 (4.3 %)	8 (34.8 %)	12 (52.2 %)	1 (4.3 %)
Enter a maritime domain, that is not included, in the land register (v5)	3 (13.0 %)	2 (8.7 %)	8 (34.8 %)	3 (13.0 %)	6 (26.1 %)	1 (4.3 %)
Define port tariffs (dues and fees) according to competition in the surrounding area (v6)	0 (0.0 %)	1 (4.3 %)	2 (8.7 %)	10 (43.5%)	9 (39.1 %)	1 (4.3 %)

Considering that these variables are ordinal (sequential) ones, Friedman's test for dependent variables was used to determine whether the differences between these six statements are statistically significant. The results are shown in Table 3 and Table 4.

Table 3.
Comparison of the average rank of importance of a claim of what needs to be done on the maritime domain of the Split Port Authority to encourage greater economic development.

Options	Average rank
Invest in optimizing a superstructure that has so far not been appealing to economic entities	3.21
Build an infrastructure that would better connect the port with its gravitational area	3.67
Establish an integrated port IT system	3.29
Build infrastructure that will encourage and attract the presence of different forms of maritime traffic	4.12
Enter a maritime domain, that is not included, in the land register	2.67
Define port tariffs (dues and fees) according to the competition in the surrounding area	4.05

Table 4.
Friedman's test of the difference in the importance of the claims of what should be made on the maritime domain of the Split Port Authority to encourage greater economic development.

N	21
Chi-Square χ2	13.796
df	5
Asymp. Sig. (p)	0.017

Friedman's test for dependent variables shows that the importance of these six statements differs significantly ($\chi 2 = 13.796$; $df = 5$; $p = 0.017$; $p < 0.05$), and that construction of infrastructure that will encourage and attract the presence of different forms of maritime traffic is the most important assertion.

The median importance of the claim that it is necessary to build an infrastructure that will encourage and attract the presence of different forms of maritime traffic, which was greater than 3.5, was eligible to be tested by a Sign Test, suitable for ordinal variables. The results are shown in Table 5 and Table 6.

Table 5.
Deviation of the importance of the claim that it is necessary to build an infrastructure that will encourage and attract the presence of different forms of maritime traffic, concerning the median of 3.5.

		N
Build infrastructure that will encourage and attract the presence of different forms of maritime traffic (median – 3.5)	Negative differences a	2
	Positive differences b	20
	Equally c	0
	Total	22

a < 3.5; b > 3.5; c = 3.5

In the surveyed sample of 22 respondents, only two considered this statement to be of 3 or less (totally irrelevant, irrelevant or not important or irrelevant), while the other 20 considered it as important or completely important.

Sign Test has shown that the median relevance of this claim is statistically significantly greater than 3.5 ($p \approx 0$; $p < 0.01$), which indicates that it can be accepted and that at least half of the respondents consider this statement to be either important or fully relevant.

Table 6.
Deviation of the importance of the claim that it is necessary to build an infrastructure that will encourage and attract the presence of different forms of maritime traffic, concerning the median of 3.5.

	Build infrastructure that will encourage and attract the presence of different forms of maritime traffic (median – 3.5)
Exact Sig. (p)	0.000 [a, b]

a-Sign Test; b-Binomial distribution used

6. DISCUSSION

The Friedman test showed that the most important variable for stimulating greater economic development was variable v4 (the median value of 4.12), on the construction of an infrastructure that will encourage and attract the presence of different forms of maritime traffic ($p = 0.017$; $p < 0.05$). The application of the Sign Test confirmed the above mentioned statement by valorizing the results where at least half of the respondents consider building infrastructure, that will stimulate and attract the presence of different forms of maritime traffic in order to achieve greater economic development, as important or completely important ($p \approx 0$; $p < 0.01$). According to concessionaires' statements, the median value above 3.5 missed only two respondents. The variable v6, stating the need to define port tariffs (dues and fees) according to the competition in the surrounding area, got the median of 4.05, but generally, this possibility is well – known already and is out of concessionaires' competency. It is domain of the Port Authority price policy and does not require any kind of investment. The last variable getting the median above 3.5 (3.67), on building an infrastructure that would better connect the harbor with its gravitational area (v2) is related to the problematic of connectivity, also a well – known factor of competitiveness among ports, implicating that investment in port infrastructure and superstructure must be followed with the investment into traffic network. Considering that the last two variables represent already well – known facts, they were not further analyzed.

When assessing the objectivity of the concessionaires' responses, neither their private interest in taking certain measures on the maritime domain should be neglected. In this way, the elected answers are at least partially motivated by the interest of their own business.

The presence of various aspects of maritime traffic in a port creates the preconditions for dispersed economic activities both

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in the port and surrounding area. The advantages of the presence of the various aspects of maritime traffic and, consequently, the related economic activities, are especially important in times of major disturbances in the market on which, given the international character of maritime traffic and the global impacts arising there from, it can't be significantly influenced. If a certain port business activity of maritime traffic recorded a traffic decline (in 2017, the Port of Split recorded a decrease in passenger and vehicle traffic on international voyages, but also an increase in the number of passengers and vehicles in domestic traffic with total growth by 6 %) (CBS, 2017), there is a possibility to compensate the decrease of certain traffic activity by increase of other form of traffic that exists in the port. It is necessary to develop the port infrastructure and superstructure that increases the port capacity and thus creates preconditions for attracting various aspects of maritime traffic. Furthermore, it is extremely important to study the traffic trends in the surrounding ports (which are, as a rule, also the main competitors), to identify the possibility to attract additional modes of maritime traffic. In addition to investment in port infrastructure and superstructure, additional traffic can be attracted by stimulating tariff policy of entities involved in shipping and shipping costs. Businesses operating in the port area have direct benefit of increasing the existing traffic or attracting a new form of maritime traffic (including cargo traffic activities) in order to negotiate a reduction of their service prices and ability to work together towards acquiring potential new users of their services. All these suggested measures affect and increases the level of port competitiveness.

According to the legal regulations of the Republic of Croatia, the Port Authority has been established to manage maritime domain (ports), meaning that it should invest, build and maintain the port infrastructure and superstructure. Port Authority, as a non-profit state institution, accumulates income from port dues and fees as well as concession fees and reinvests the retrieved revenue in the development of the port area. It is therefore of the utmost importance that the management of the port administration has a clear vision in which direction the port should be developed through investments in the port infrastructure and superstructure. Furthermore, authorized concessionaires may also invest in the port area if they have valid permission for these activities. Port authorities should work to improve attractiveness of the port area for investments of potential concessionaires.

7. CONCLUSION

The main implication and recommendation of concessionaires performing business activities in the related port area is to build infrastructure at maritime domain under the management of the Split Port Authority that will encourage and attract the presence of different forms of maritime traffic and in that way, increase maritime transport and strengthen the economic development of the city. The provision of suggested measures would probably improve the concessionaires' business results too. Continuous and systematic investment in port infrastructure and superstructure is needed. In this way the port system can better deal with the changing demand of maritime transport and as an overall result, generate positive economic effects and development.

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Analysis of Overall and Pure Technical Efficiency of Tourism in Europe

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The aim of this paper is to assess the overall and pure technical efficiency of tourism in European countries in 2017 using the output-oriented Charnes, Cooper and Rhodes (1978, 1979), and Banker, Charnes and Cooper (1984) data envelopment analysis methodology. The countries were divided into two groups: European Union countries and non-European counties. We identified two input and two output variables for each group. Input variables were identified using the principal component analysis method, starting from fourteen pillars that measure the performance of countries in the field of travel and tourism, and are published in the regular reports of the World Economic Forum. Then, two output variables were defined (the total (direct and indirect) contribution of travel and tourism to gross domestic product, and the direct contribution of tourism to employment growth rate), to determine the relative efficiency of decision-making units within the formed homogeneous groups of countries, among which the group of Western Balkan countries was singled out. This analysis enabled us, based on relatively scarce potential, to propose guidelines for a tourism development strategy for the entire Western Balkans region.

KEY WORDS
~ Tourism
~ Technical efficiency
~ DEA
~ Methodology

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1. INTRODUCTION

Globally, tourism is one of the most dynamic and fastest growing economic activities, which has, unlike other economic activities, been characterized by continuous growth and development, especially over the last two decades. Although tourism is primarily perceived as an opportunity for accelerated economic development in many countries, it simultaneously requires economic policy holders to face a range of challenges and show willingness to perform complex tasks to create the conditions for cooperation between a large number of business entities, both at the national and international level. In addition to numerous economic and social opportunities, the development of tourism contributes to greater international openness and geographic connectivity of the country, resulting in increased income and the development of cheap air transport as an accompanying and necessary element of successful development.

As a matter of fact, strong development of tourism increases opportunities for employment and raises income levels, improves living standards and contributes to the elimination of a number of financial and institutional barriers. Unsurprisingly, low- and middle income level countries are particularly keen on its development. Tourism is seemingly the most realistic development concept, since the inputs necessary for competitive positioning at international level are not insurmountable, as is the

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case with technologically-intensive branches. Moreover, tourism is a labor-intensive branch of economy with high added value, its development undoubtedly opens new jobs and is characterized by growing employees' incomes, confirming that it is a branch that does not build its competitiveness on cheap labor.

If we analyze the tourism offer of a country or a region, it should be emphasized that it is most commonly based on natural and cultural-historical components that are most often present in underdeveloped and passive areas. Today, the competitiveness of such resources is largely dependent on innovative ideas and marketing strategies aimed at attracting more tourists in order to ensure a balanced and unified regional development (Jakšić-Stojanović and Šerić, 2018). From the point of view of demand, the prospects and the potential for expansion are relatively unlimited, giving even underdeveloped economies an opportunity to identify their potentials relying on pre-existing inputs and reap the benefits of tourism with minimum investment.

By definition, the efficiency of tourism industry is the extent to which a particular region exploits its tourism resources (Luo and Qian, 2017). Starting from the definition of tourism efficiency, the purpose of this research was to measure and analyze the relevance of efficiency of investment into tourism in European countries, with a particular focus on the Western Balkan countries. Our aim is to point out the problems and sources of inefficiency of tourism in Western Balkan countries and, accordingly, propose guidelines for a development strategy that will increase the relevance of tourism in these countries. Proposal guidelines will be based on an empirical study of best practices of various forms of year-round tourist offer at the global level. In line with innovative trends in tourism, the proposed efficiency improvement measures will be based on the development of certain specialized tourism products.

2. LITERATURE OVERVIEW

Previous studies in this area mainly focused on the assessment of tourism efficiency of provinces, regions, countries or even groups of countries, and were carried out in order to define tourism development strategies which would provide guidelines for easier and more efficient placement of existing or new tourism services to potential tourists.

Botti, Peypoch, Robinot and Solonandrasana (2009) examined the tourism efficiency of 22 regions in France using the output-oriented data envelopment analysis (DEA) methodology. The analysis was based on the number of tourists as the output variable and on 6 input variables: number of hotels, camps, parks, monuments, museums and miles of available beaches. Technical efficiency was achieved in 10 regions, which can serve as examples of good practice and benchmarks for increasing efficiency in the remaining regions. Similar analysis was performed by Barros, Botti, Peypoch, Pobinot, Solonandrasan and Assaf (2011). The analysis also included 22 French regions in the period 2003- 2007 and was based on the application of the two-stage DEA method. In the first stage, efficiency coefficients for each region were estimated based on two input variables (accommodation capacities and number of tourist arrivals) and one output variable (number of overnight stays). In the second phase, using regression analysis with the inclusion of variables representing tourist attractions (monuments, museums, parks, beaches, ski resorts and natural parks), the authors came to the conclusion that the efficiency is most dependent on sea exit and coast tidiness. The proposed development strategy for regions which do not meet these requirements is to increase the number of theme parks, monuments, ski resorts and nature parks. The authors believe that the expansion of the tourist offer and the number of tourist attractions increase the efficiency of the least developed tourist regions. Encouraged by the importance of tourism for a country's economy and the growth of tourism market competitiveness due to the transition from mass tourism to the specific needs of tourists, Cracolici, Nijkamp and Rietveld (2008) analyzed the technical efficiency of destinations from 103 regions in Italy in 2001. Competitiveness in terms of technical efficiency was examined by using the parametric stochastic frontier analysis (SFA) and the nonparametric DEA method. The SFA method showed variability in terms of effectiveness across the region, indicating that regions with artistic and cultural attractions were better rated than mountainous or coastal regions. Some lower efficiency scores were obtained by using the DEA method, due to the insufficient homogeneity of observed regions. Gucci and Rizzo (2013) applied two-stage DEA method to establish the extent to which UNESCO nominations determined the efficiency of tourist destinations and the flow of tourist travels in Italian regions in 1995-2010. The results showed that although UNESCO nominations had a negative short-term impact on the efficiency of tourist destinations, their long-term impact was not statistically significant. This is because tourists value cultural content and natural attractions when choosing a destination, which UNESCO-nominated destinations mostly miss. In order for UNESCO nominations to have a positive impact on efficiency, it is essential that such sites are made accessible to tourists, secured with material and immaterial infrastructure and enriched with cultural events. Encouraged by such analyses, many authors have tried to evaluate the tourism efficiency of the less developed European countries in order to develop a strategy for increasing their competitiveness, and thus the exploitation of both natural and cultural-historical components that are frequently found in underdeveloped areas. One such study was conducted by Tom (2014), who examined the efficiency of 8 regions in Romania in 2012, using the input-oriented DEA method with 4 input and 5 output variables. The analysis examined the efficiency of 5 regions. One region was technically inefficient due to the supply of tourist capacities surpassing demand, while 2 were inefficient because the tourist demand for accommodation facilities grew faster than supply. In the Asian market similar analysis was performed by Bi, Lou and Liang (2014). The analysis evaluated the efficiency of 31 provinces in China through two stages defined as the capacity building stage and the benefit creating stage. In the first stage there were 19, and in the second 22 efficient provinces, but according to the overall estimate, only 6 provinces had efficiency scores equal to one (Beijing, Inner Mongolia, Shanghai, Henan, Qinghai and Ningxai), while the worst-rated province was Hebei with an efficiency score of 0.3890.

Of the studies that included a group of countries from one or more regions, we will mention only those analyzing the efficiency of European countries, given that such analyses are the closest to the research that will be carried out in this paper. Cvetkoska and Barišić (2014) measured the efficiency of 15 European countries (Austria, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, France, Greece, Italy, Macedonia, Montenegro, Portugal, Serbia, Slovenia and Spain) in 2004-2013 using Window-DEA analysis method. By selecting two input and two output variables, with the formation of 6 windows covering 5-year periods, the highest efficiency scores were achieved in 2004, and the lowest in 2011. According to results, no country achieved full efficiency in all years and in all windows, but 10 out of 15 countries had an efficiency coefficient of over 0.95. Montenegro was identified as the country with the lowest efficiency, while four countries with the highest scores were: Italy, Cyprus, France and Spain. Kosmaczewska (2014) analyzed 27 EU member countries in 2007-2009. The results have shown that wealthier countries have achieved a higher level of technical efficiency, while developing countries have reached a higher level of scale efficiency. This can be explained, inter alia, by the fact that tourism development largely depends on investments, which are more easily available in wealthier countries. However, opportunities for efficiency improvement in wealthier countries are ever decreasing, given that the tourist services that these countries offer are already at an extremely high level of development. At the moment, this does not leave much room for investors, who have been increasingly turning to developing countries in search of opportunities to increase their capital. Developing countries or groups of developing countries which constitute one region, first of all, should recognize their competitive advantages over other countries and accordingly develop strategies that will attract investors and potential tourists. In a comprehensive list of research results, it is interesting to note the study of authors Martín, Mendoza and Román (2015), who have created a unique competitiveness index at the global level and ranked 139 countries using the DEA method, by analyzing their geographic position and national income. Describing the differences in the characteristics of the best and worst-rated countries, and their geographic areas, this paper has made a significant contribution to the mapping of profiles that in the near future can be used by economic policy-makers to form strategies that will maximize their use and increase their tourism potential.

All efforts in literature so far enable future authors to use the DEA method in their research to a greater extent, which will, in combination with other parametric and nonparametric methods, provide relevant assessments of tourism efficiency (Šerić and Ljubica, 2018). This study as well will focus on the evaluation of efficiency of tourism in European countries, based on which the Western Balkan countries will be positioned in terms of efficiency, with the aim of proposing guidelines for a tourism strategy oriented on the expansion of the tourist offer through innovative forms of tourism and the development of specialized tourist products (Jakšić-Stojanović and Šerić, 2018).

3. METHODOLOGY

3.1. Charnes, Cooper and Rhodes (CCR) DEA Model

The non-parametric DEA method was proposed by Charnes, Cooper and Rhodes (1978), to define the relative measure of efficiency of the decision-making units when a large number of output and input variables are present. The relative measure of efficiency using the DEA method is determined by the ratio of weighted output values and weighted input values for each individual observed unit. The observed units are compared with each other by the formation of a linear programming model. The efficiency frontier is composed of observed units with the best business practices, while the efficiency of all other units is determined on the basis of the distance from the defined efficiency frontier. Units at the frontier are considered relatively efficient, while those out of the frontier are relatively inefficient. A set of efficient units is viewed as a reference point for proposing improvements to relatively inefficient units (Prorok and Bošnjak, 2018).

Suppose we have $_n$ decision-making units (DMUs) and that each of the units DMU_j, $(j = ,2, ..., n)$ produces s outputs of the same type and of different values, y_{rj} $(r = 1, 2, ..., s)$, using different m input values of the same type, x_{ij} $(i= 1, 2,...,m)$.

The CCR model is designed to obtain for each k- the decision-making unit DMU_k (k= 1, 2,..., n) the optimization task of the relationship between the virtual output and the virtual input, in order to determine the weight coefficients for the output and input variables to which the value of the relationship will be maximized:

$$(max)\, h_k = \frac{\sum_{r=1}^{s} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}} \qquad (1)$$

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with the following constraints:

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1, \quad j = 1, 2, \ldots, n \tag{2}$$

$$u_r \geq 0, \quad r = 1, 2, \ldots, s \tag{3}$$

$$v_i \geq 0, \quad i = 1, 2, \ldots, m \tag{4}$$

where: h_k - the relative efficiency of the k-th decision-making unit; n - the number of decision-making units; m - the number of inputs; s - the number of outputs; v_i - weight coefficients for input i; u_r - weight coefficient for output r ; x_{ij} - the amount of input i for the j-th decision-making unit, (DMU_j) ; y_{jr} - the amount of output r for the j-th decision-making unit, (DMU_j).

3.2. Banker, Charnes and Cooper (BCC) DEA Model

The presented CCR model assumes that the observed units achieve constant returns to scale, i.e. the increase in the value of the engaged inputs by a certain percentage results in the same or approximately the same percentage of output increase. For this reason, the efficiency frontier formed on the basis of the CCR model has the shape of a convex cone.

All observed units positioned at the frontier of efficiency are considered to have full overall technical efficiency that includes both pure technical efficiency and the efficiency of scale. Baker, Charnes and Cooper (BCC) proposed the measurement of pure efficiency by extended basic CCR DEA model in 1984.

BCC model provides an assessment of pure efficiency, excluding the effect of the business scale by comparing the observed units exclusively to other units of similar size.

The mathematical formulation of the BCC model, unlike the CCR model represented by the expressions (3.1)-(3.4), includes an additional variable u^*. The decision on whether the additional variable will be included in the numerator or the denominator depends on whether the general form of the BCC model is transformed into a linear programming model with output or input orientation. The purpose of introduction of an additional variable is to set up a constraint on returns to scale and to ensure the formation of the reference set on the basis of a convex combination of decision-making units (Prorok and Bošnjak, 2018).

The general formulation of the BCC model is given by:

$$(max)\, h_k = \frac{\sum_{r=1}^{s} u_r y_{rk} - u^*}{\sum_{i=1}^{m} v_i x_{ik}} \tag{5}$$

With the following constraints:

$$\frac{\sum_{r=1}^{s} u_r y_{rj} - u^*}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1, \quad j = 1, 2, \ldots, n \tag{6}$$

$$u_r \geq \varepsilon, \quad r = 1, 2, \ldots, s \tag{7}$$

$$v_i \geq \varepsilon, \quad i = 1, 2, \ldots, m \tag{8}$$

3.3. Window DEA Analysis

Window DEA analysis is a specific form of the DEA method that allows the changes in the efficiency of the observed units to be observed over a given period of time. The method involves defining windows covering multiple time frames, where each observed unit is treated as a separate observed unit at different times. This allows the comparison of the efficiency of not only one unit over time, but also its comparison with other units that are covered by the defined window.

The Window DEA analysis allows us to increase the number of observed decision-making units and to include the time dimension of the data by analysis. However, the main disadvantage of this method is that, by moving windows, certain time units are tested several times, while time frames corresponding to the first and last periods are tested only once, because they are only covered by the first and last window, respectively.

The Window DEA analysis will be used in this paper to test the overall and pure technical efficiency of insurance companies in Bosnia and Herzegovina and rank the most efficient decision-making units based on average efficiency estimates, both through windows and time periods. (Prorok and Bošnjak, 2018)

4. IDENTIFICATION OF INPUT AND OUTPUT VARIABLES FOR THE EVALUATION OF EFFICIENCY OF TOURISM IN EUROPEAN COUNTRIES

4.1. Identification of Input Variables

Although the DEA method is an excellent optimization technique for the assessment of tourism efficiency, certain limitations still exist. Limitations occur when the number of input and output variables is relatively high compared to the number of observed units. One of the ways to overcome this limitation might be to introduce only those variables (inputs and outputs) in the model which are the basic components of the production process. In this way, not only are the outcomes of the DEA method not affected, but it becomes even more effective.

In our evaluation of tourism efficiency in European countries, we tried to eliminate the shortcomings of the DEA by dividing countries into relatively homogeneous groups, depending on the resemblance of their available tourist resources, and adjusting the number of the defined input and output variables to the number of observed units. Key input variables were identified using the principal component analysis method, starting with the 14 pillars for the measurement of the performance of countries in the field of travel and tourism, which are published in the regular reports of the World Economic Forum (WEF).

In the 2013 report, the pillars were divided into three categories: Travel & Tourism (T&T) regulatory framework, T&T business environment and infrastructure, and T&T human cultural, and natural resources. However, as of 2015, the pillars have been divided into four categories: Enabling Environment, T&T Policy and Enabling Conditions, Infrastructure, and Natural and Cultural Resources. The index of travel and tourism competitiveness is formed on the basis of the aforementioned categories and measures the performance of countries in the field of travel and tourism.

Given that first the countries and then tourist regions differ by the degree of tourism competitiveness achieved, it can be assumed that not all factors will have the same impact on the tourist performance of these countries. Therefore, the aim was to identify the main components that contributed to the competitiveness of tourism in European countries in 2017. We divided the countries into two groups: the EU member countries (28 countries) and countries outside the European Union (14 countries).

Two principal components were identified in both groups. In EU member countries, we noted that all variables with the highest factor load, which make up the first component, had positive signs, namely: *1) Business Environment, 2) Human resources and labor market, 3) Information and communication technology (ICT) Readiness, 4) International openness, 5) Environmental Sustainability, 6) Ground and port infrastructure*; while the second component consists of variables: *1) Prioritization travel and tourism, 2) Price competitiveness, 4) Air transport infrastructure, 5) Tourist service infrastructure, 6) Natural resources, 7) Cultural resources and business travel*, of which only the Price competitiveness variable had negative, while other variables had positive factor load. This suggests that if a given country is rated positively as a tourist destination for one attribute within the component that it determines, it will probably be highly rated by other attributes with the same sign within that component. On the other hand, countries that have highly rated attributes with a positive sign are likely to have some poorly rated attributes with a negative sign. Specifically, in our case, countries from the EU 28, belonging to a group in which tourism is dependent on the second component, are likely to have poor ratings in terms of price competitiveness, if they have highly rated other variables that are mainly related to air transport, tourist infrastructure, and natural and cultural resources.

A similar structure of components was also noted in non-EU countries. The first component consists of the following group of variables: *1) Business Environment, 2) Safety and security, 3) Human resources and labor market, 4) ICT Readiness, 5) Prioritization travel and tourism, 6) International openness, 7) Price competitiveness, 8) Environmental Sustainability, 9) Ground and port infrastructure; 10) Tourist service infrastructure*; while the second component consists of three variables, namely: *1) Air transport infrastructure, 2) Natural resources, 3) Cultural resources and business travel*.

The identified main components were used as input variables in the assessment of tourism efficiency.

Having identified the main components, we conducted cluster analysis to group the countries into appropriate clusters according to the similarity of the tourism resources available to them. Hierarchical cluster analysis and k-means cluster analysis were used to determine the number of clusters and place the countries into the corresponding cluster. The analysis classified EU member states into 4 groups, and non-EU countries into three groups. Based on the ANOVA analysis, we confirmed that the clusters thus formed, within both observed groups of countries, were statistically significant.

The following table presents the results of cluster analysis, and defines positively and negatively profiled components for each cluster individually.

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Table 1.
Countries grouped by clusters – for EU and non-EU countries.
Source: Prorok et al. (2017).

Clusters for EU countries					Clusters for non-EU countries		
C1	C2	C3	C4		C1	C2	C3
Austria, Germany, United Kingdom, Ireland	France, Italy, Greece, Portugal, Spain, Cyprus, Malta, Croatia	Luxembourg, Netherlands, Denmark, Finland, Sweden	Belgium, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia, Bulgaria, Romania		Switzerland, Norway, Iceland	Turkey, Ukraine, Russia	Serbia, Bosnia and Herzegovina, Macedonia, Albania, Montenegro, Moldova, Georgia, Armenia
PC1	PC2 and PC1	PC2	Countries where both defined components are negatively profiled and do not currently contribute to the tourism competitiveness of the countries.	Similar to the profile defined by:	PC1 and PC2	PC2	Countries where both defined components are negatively profiled and do not currently contribute to the tourism competitiveness of the countries.
PC2	PC1			Unlike the profile defined by:		PC1	

4.2. Output Variable Identification

The development of tourism as an economic branch has a strong influence on both economic and non-economic aspects of development. The economic functions of tourism are reflected in its direct influence on: social product and national income, development of underdeveloped areas, balance of payments and employment; while its indirect influence is visible in the increased development of production of materials (industry, construction, agriculture) fueling the tourism industry. The non-economic or social aspects of tourism development relate primarily to the following functions: health, entertainment, cultural, social and political. The non-economic or social aspects of tourism development relate primarily to the following functions: health, entertainment, cultural, social and political. These functions stand out as crucial for the development of a country's tourism, and their neglect would undermine the practicality of treating tourism as a development option.

Given that this paper deals with the efficiency of tourism from an economic standpoint, our analysis focuses on economically measurable indicators of total (direct and indirect) contribution of travel and tourism to GDP and on the contribution of travel and tourism to employment. The two variables mentioned above will be used as output variables when evaluating tourism efficiency using the DEA method.

The World Travel and Tourism Council continually publishes data on total tourism contributions to GDP, which is methodologically consistent with the UNWTO (TSA RMF 2008) recommendation, and corresponds to GDP calculation in national accounts (Đuranović and Radunović, 2011).This aggregate is also an indicator of the shift of social products from economically developed to economically less developed countries. In this way, a more uniform development of the world's power is achieved.

In addition to its contribution to GDP, it is important to look at the impact of tourism on employment, i.e. opening of new jobs. The largest number of jobs is created in the hotel and restaurant sector, as well as in other supporting activities. It should also be emphasized that tourism has been opening jobs for staff of different degrees of expertise and education for years. This trend continues, with growing demand for highly flexible staff, possessing adequate competencies and capabilities to meet future tourism needs. Also, the World Economic Forum regularly publishes data on the contribution of tourism to total employment, reflecting the actual state of affairs.

5. EVALUATION OF EFFICIENCY OF TOURISM IN EUROPEAN COUNTRIES

The overall and pure technical efficiency of tourism in European countries was assessed by using the output-oriented CCR and BCC model. Two groups of countries were observed. The first group consists of 28 EU member states, while the other group consists of 14 countries outside the European Union, including

Table 2a.
Evaluation of overall and pure technical efficiency of EU countries in 2017, using output-oriented CCR and BCC DEA models.
Source: Authors' calculations.

Country (DMU)	CCR efficiency score	Rank	BCC efficiency score	Rank
Cyprus	1	1	1	1
Malta	1	1	1	1
Bulgaria	1	1	1	1
Portugal	0.9911	4	1	1
Croatia	0.9225	5	1	1
Greece	0.7269	6	1	1
Estonia	0.6906	7	1	1
Ireland	0.6901	8	1	1
Poland	0.6761	9	1	1
Sweden	0.6116	10	1	1
Spain	0.5804	11	1	1
Romania	0.5493	12	1	1
Slovenia	0.5336	13	1	1
Netherlands	0.507	14	1	1
Italy	0.4797	15	1	1
Latvia	0.4126	16	1	1
Czech Republic	0.389	17	1	1
Finland	0.3722	18	1	1
Hungary	0.3587	19	1	1
Denmark	0.3453	20	1	1
Slovakia	0.3421	21	1	1
Luxembourg	0.2756	22	1	1
Belgium	0.2511	23	1	1
Lithuania	0.2197	24	1	1
Austria	0	25	0.0001	25
France	0	25	0	26
Germany	0	25	0	26
UK	0	25	0	26

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the West Balkans. For both groups of countries, we determined two input and two output variables for efficiency evaluation. Input variables for both groups of countries were obtained on the basis of rating of 14 pillars defined in the annual report on tourist competitiveness of countries in 2017, and released by the World Economic Forum (WEF). We reduced the number of input variables by applying the principal component analysis (PCA) method. Thus, two input components were formed for both groups of countries, based on a linear combination of 14 defined pillars. Given that the linear combinations for the observed groups of countries were different, their efficiency had to be evaluated separately. The structure of the principal components was presented in the previous chapter. For output variables, data on the total contribution of travel and tourism to GDP, and data on the direct contribution of travel and tourism to the rate of employment growth, where both variables were expressed in percentages, were used. Data on output variables are from 2017 and were downloaded from the World Data Atlas site (https://knoema.com/atlas).

Tables 2a and 2b illustrate the results of the overall and pure technical efficiency of EU countries and non-EU countries using the output-oriented CCR and BCC DEA models. Countries are ranked by their tourism efficiency. For analysis purposes, we used the DEA-Solver-LV software package.

The results for EU member states show that the following countries received the highest ratings for overall technical efficiency: Cyprus, Malta and Bulgaria. The efficiency coefficient value for the three mentioned countries is 1, indicating that these countries have reached total technical efficiency within the observed set of countries and that they represent a reference set against which the relative efficiency of other countries is assessed. Slightly lower efficiency scores were realized by Portugal (0.9911) and Croatia (0.9225), followed by Greece (0.7269), Estonia (0.6906), Ireland (0.6901), etc. It should be noted that, judging from the defined output and input variables, countries such as Austria, France, Germany and the UK have proven to be completely inefficient compared to the reference units.

When it comes to non-EU countries, the most efficient units, with the efficiency coefficient of 1, were the following countries: Turkey, Albania, Montenegro, Georgia, Ukraine and Armenia; while relatively inefficient countries were: Moldova (0.8913), Macedonia (0.7826), Bosnia and Herzegovina (0.6115), Serbia (0.4268), etc.

From the Western Balkan countries, which according to defined input variables belong to cluster 3, Albania and Montenegro had the highest efficiency scores, while Macedonia, Bosnia and Herzegovina and Serbia achieved relatively poor overall technical efficiency scores.

It should be noted that same efficiency scores would be obtained with the input-oriented CCR model, with the orientation being different.

Table 2b.
Evaluation of overall and pure technical efficiency of non-EU countries in 2017, using output-oriented CCR and BCC DEA models. Source: Authors' calculations.

Country (DMU)	CCR efficiency score	Rank	BCC efficiency score	Rank
Turkey	1	1	1	1
Albania	1	1	1	1
Montenegro	1	1	1	1
Georgia	1	1	1	1
Ukraine	1	1	1	1
Armenia	1	1	1	1
Moldavia	0.8913	7	1	1
Macedonia	0.7826	8	1	1
Bosnia and Herzegovina	0.6115	9	1	1
Serbia	0.4268	10	1	1
Russia	0.3057	11	1	1
Iceland	0.004	12	0.9999	12
Switzerland	0	13	0.0001	13
Norway	0	13	0	14

The results of the assessment of pure technical efficiency of EU member countries show that most countries achieved full efficiency. Countries that did not achieve pure technical efficiency are France, Austria, Germany and Great Britain. The pure technical efficiency coefficient for these four countries is zero. However, given that the coefficient of their overall technical efficiency is zero, and that, according to a large number of tourism indicators (revenues from tourism, number of employees in tourism, etc.) they are ranked relatively high; we can conclude that these countries achieve tourism development through the efficiency of scale.

Likewise, almost all non-EU countries achieved pure technical efficiency, with only Switzerland and Norway having the coefficient of efficiency equal to zero. It should also be noted that all Western Balkan countries had the pure technical efficiency coefficient of 1. Albania and Montenegro, in addition to achieving pure technical efficiency, also achieved the efficiency of scale, because their coefficient of overall technical efficiency is 1. Countries that had a lower coefficient of overall technical efficiency, with a high value of coefficient of pure technical efficiency, did not achieve efficiency in terms of scale. This is the case with countries such as Macedonia, Bosnia and Herzegovina, and Serbia. In other words, lower CCR coefficient value combined with high BCC value, mean that these countries are locally but not globally efficient, which is again a consequence of inefficiency of scale. Inefficiency of scale may be the result of inefficient operational activities and / or conditions unfavorable for the development of tourism.

It is particularly interesting for purposes of this research to note the position of the Western Balkan countries in relation to other countries, primarily those that are not part of the EU. Using the principal component analysis method and then the cluster method, we grouped West Balkans countries into one cluster (C3) and showed that none of the two defined components currently contributes positively to the overall tourist competitiveness of these countries. This resulted in lower scores of total technical efficiency, and consequently, of efficiency of scale. Economic policy makers should interpret this as an indication of the need to draw up strategies and operational measures in the field of tourism.

The achievement of global efficiency requires a tourism development strategy for the entire region. The strategy should be based on innovative trends in tourism, for which there are enormous potentials in the Balkans.

6. CONCLUSION AND DISCUSSION

In this paper we evaluated the overall and pure technical efficiency of tourism in European countries using CCR and BCC DEA methods. We divided the countries into two groups: EU countries and non-EU countries. Two input and two output variables were identified for each group. Input variables were presented by linear combinations of 14 pillars on the basis of which The Travel and Tourism Competitiveness Index (TTCI) is formed. Countries were clustered on the basis of defined input variables, using the cluster method to form relatively homogeneous decision-making units that have similar or identical tourism potentials, from the point of view of natural resources, cultural and historical heritage, geographical location, infrastructure, etc. In that sense, cluster C3, to which Western Balkan countries belong, was distinguished as a special cluster within non-EU countries. The aforementioned cluster is characterized by negative profiles of both principal components. In addition, by defining output variables, we estimated the relative efficiency of all observed units. Analysis results facilitated the identification of advantages and disadvantages of post-transition countries in terms of their tourism competitiveness.

Among Western Balkan countries, Albania and Montenegro have been most effective in achieving full and pure technical efficiency compared to other observed units from the group of non-EU countries. Bosnia and Herzegovina, Serbia and Macedonia have achieved lower coefficient of total technical efficiency, while their coefficient of pure technical efficiency was one. These results indicate that the three mentioned post-transition countries are ineffective in terms of scale, possibly as a result of the non-existence or inefficient implementation of operational activities in the field of tourism, as well as of unfavorable conditions for its development. Therefore, if these countries are to improve their tourist competitiveness, they should pursue tourist offer based on relatively inexpensive and pre-existing resources that do not require significant investments. This can be achieved through the development of specialized tourism products based on innovative trends in tourism, for which Western Balkan countries have enormous potential. These forms of tourist offer could include various subtypes of health tourism, dark tourism, cultural tourism, educational tourism, etc. Such a tourism development strategy for the entire West Balkans region, would give these countries an opportunity to become globally recognizable and significantly improve their competitiveness. The presented findings of the research conducted indicate that the identification of the causes of the modest contribution of tourism to the GDPs of most non-EU countries of the West Balkans requires more detailed individual analysis.

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External Costs on The Island of Vis: Comparison of two Traffic Modes

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External cost of road traffic, identified as the highest among traffic modes, is an important indicator of the European Union's transport policy to shift traffic off the road to a more environmentally acceptable mode. Ferry traffic generates benefits to each port of call in localities having invested in port infrastructure, and there is an interest of the local community to have their own ferry line, especially on islands. Two alternative ferry lines have been created combining maritime and road traffic on the specific route from the town of Vis to the town of Komiža and compared from the external costs standpoint. The first alternative ferry line comprises one port of call in the town of Vis, combining it with a road modality to and from the town of Komiža. In the second alternative, the road traffic has been excluded and two ferry ports of call have been introduced, one towards the town of Vis and the other by extending the ferry voyage to the town of Komiža. The results show the model of one port of call with the integration of more road traffic on the specific route as a better solution. Despite the use of ultra-low sulphur diesel fuel on ferries, the absence of congestion in road traffic on the island of Vis and generally slow implementation of modern emission standards in maritime traffic, road traffic seems to provide a better solution as an environmentally more acceptable mode on this route.

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~ External costs
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1. INTRODUCTION

Current EU transport policy pays special attention to the socio-ecological aspect of transport and sustainability (EC, 2009), while external costs are an important tool for measuring the impact of traffic on environment and health (Van Lier, 2016). Road traffic is known as the worst traffic polluter with external costs mainly due to traffic congestion, accidents, and emissions (Maibach et al., 2008). Maritime traffic is more often relieved of congestion and accidents and involves only emission pollutants. For this reason, it is considered to be an environmentally acceptable means of transport. On the islands, where maritime traffic links are particularly important for providing benefits in each port of call (Luttenberger, 2012), there is a great deal of local community interest in establishing their own ferry line. However, the inclusion of external costs in practice as a market-competitive criterion is not so easy and paradoxical results are not uncommon. Each traffic route should be examined and evaluated from the external costs point of view, in order to determine which mode of transport is the most environmentally acceptable (Vukić & Poletan Jugović, 2016). The research shows such an example from the island of Vis in Croatia.

2. AIM

On the island of Vis, there are two main towns: Vis and Komiža. They are connected by road and naturally, by sea. Both towns have the ports suitable for ferry traffic. But only the town of Vis is connected to the mainland by a ferry line. Vehicles with a final destination in the town of Komiža disembark in the town of Vis and continue the journey by road carrying the stigma of high external costs. The survey examines whether or not the external costs would be lower in case of further travel from the town of Vis to the town of Komiža by ferry.

3. MATERIAL AND METHODS

The ferry "Petar Hektorović" travels from Split to the town of Vis. The distance of voyage is 35 M and it lasts for 2 hours and 20 minutes. It is powered by two KRUPP-MaK diesel engines of 1800 kW each (ShipSpotting, 2018). Combustion is 210 g/kWh of Euro diesel. The distance between the two towns on the island is 11 M by sea. The frequency of ferry lines was three times a day in 62 days in the high tourist season and two times a day in 303 days in the low season in 2017.

The road distance between two towns on the island is 10 km. The combustion of road vehicles was calculated using the models of car (capacity <2.5 t, 70 kW) and truck (capacity <7.5 t, 200 kW, speed 50 km/h). The technical data has been downloaded from the technical sheets (Table 1).

Table 1.
Characteristics of the engines of vehicles in the research.

Vehicle	Engine; Power	Fuel; Specific gravity	Combustion	Load
Car (passenger)	Otto; 70 kW	Gasoline; 0.75	7 l/100km*	75 %
Truck (HDV)	Diesel; 200 kW	Eurodiesel; 0.85	157.5 g/kWh	75 %
Ferry	Diesel; 3600 kW	Eurodiesel; 0.85	210 g/kWh	100 %

**calculated consumption value 52.5 g/km (Source: Shipspotting, 2017; Ančić, 2016; ICCT, 2016; own data – modified)*

There were 52,912 vehicles transported by this ferry line in 2017 (CLSA, 2018). According to the last census data (CBS, 2011) and the number of tourist visitors in 2017 (Split and Dalmatia County…, 2018), it is estimated that 41 % of vehicles had the final destination in the town of Komiža (Table 2).

The technical sheets have been used for the emission factor values (CO2, PM2.5/PM10, SOx, NOx) and unit prices of pollutants for each type of fuel including MDO (Marine distillate oil) that is no longer in use on ferries here (Table 3 and 4).

The unit prices of pollutants (Korzhenevych et al., 2014) have been used in order to make the range of valorisation results more understandable, not the current prices. The field research has shown that there has never been any congestion, and accidents are very rare on the road between the two towns. They have therefore been excluded from the calculation of external costs.

By multiplying the amount of fuel consumed, the emission factors and the unit prices of pollutants the external costs for all types of examined vehicles have been calculated and then compared for two alternative routes.

Table 2.
Traffic of transported vehicles on the examined ferry line in 2017, the number of tourist visitors in 2017 and the last official census in the examined destinations.
(Source: CLSA, 2018; CBS, 2011; Split and Dalmatia County..., 2018; Jadrolinija 2018)

Line/Destination	Annual number of voyages in 2017	Annual number of transported vehicles in 2017	Annual tourist visitors in 2017 (share %)	Last official census in 2011 (share %)
Split – Vis	792	52,912		
		Vis	28,394 (61 %)	1,934 (56 %)
		Komiža	17,935 (39 %)	1,526 (44 %

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Table 3.
Emission factors (EF) in road and ferry traffic (g/kg).

Vehicle	Fuel	PM10/PM2.5	NOx	SOx	CO2
Passenger car*	Gasoline - Euro 5	0.041/0.041	3.512	0.001	3,130
HDV**	Euro diesel - Euro 5	0.203/0.192	12.245	0.015	3,170
Ferry	Eurodiesel (0.001 % S)	0.203/0.192	36.66***	0.015	3,170
	MDO**** (0.1 % S)	1.6/1.5	46.58	1.158	3,170

** 0.18g/km NOx (ICCT, 2016)*

*** Heavy duty vehicle, EF 2g/kWh NOx (ICCT, 2016), Power engine 200 kW, Load 75 %*

****calculated value, Tier II, 2100 o/min, EF 7.7 g/kWh NOx, SFOC 210 g/kWh (Ančić, 2016), Power engine 3600 kW, Load 100 %*

*****Marine diesel oil (Source: Statistics Norway, 2017 – modified)*

Table 4.
Air pollution costs of main pollutants in traffic (€/t).

Vehicle	CO2	SOx	NOx	PM2.5/PM10* rural
Car (passenger)	90	12,317	15,149	31,649/5,064
Truck (HDV)	90	12,317	15,149	31,649/5,064
Ferry	90	6,700	1,850	18,500/2,960

**unit price PM10=16 % PM2.5 (TU Delft, 2012), (Source: Korzhenevych et al., 2014 – modified)*

4. RESULTS

The results of the calculation of external costs for the two alternative routes are shown in Table 5-8. Given the unknown types of road vehicles driving to Komiža, the calculation assumes that all vehicles were passenger cars in one case and that all vehicles were trucks in the other one. Calculation of external costs of a ferry using MDO shows the size of the benefit of fuel change.

Table 5.
Calculation of external costs on the route Vis-Komiža by ferry using Eurodiesel.

Vis – Komiža ferry*	Calculation
Consumption Eurodiesel	engine power x SFOC x time = fuel (kg) 3,600 x 0.21 x 0.73 = 551.88 kg
Emissions and valorization SOx NOx PM10 PM2.5 CO2 Total	emission factor x consumption x unit price = external cost (€) 0.015 x 551.88 x 6.7 = 0.06 € 36.66 x 551.88 x 1.85 = 37.43 0.203 x 551.88 x 2.96 = 0.33 0.192 x 551.88 x 18.5 = 1.96 3,170 x 551.88 x 0.09 = 157.45 external cost x no. voyages x 2 197.23 x 792 x 2 = 312,412.32 €

**distance 11 M, speed 15 kn, time 0.73 h, no. voyages 792*

Table 6.
Calculation of external costs on the route Vis-Komiža by ferry using MDO.

Vis – Komiža ferry*	Calculation
Consumption MDO	engine power x SFOC x time = fuel (kg) 3,600 x 0.21 x 0.73 = 551.88 kg
Emissions and valorization SOx NOx PM10 PM2.5 CO2 Total	emission factor x consumption x unit price = external cost (€) 1.158 x 551.88 x 6.7 = 4.28 46.58 x 551.88 x 1.85 = 47.56 1.6 x 551.88 x 2.96 = 2.61 1.5 x 551.88 x 18.5 = 15.32 3,170 x 551.88 x 0.09 = 157.45 external cost x no. voyages x 2 227.22 x 792 x 2 = 359,916.48 €

**distance 11 M, speed 15 kn, time 0.73 h, no. voyages 792 x 2*

Table 7.
Calculation of external costs on the route Vis-Komiža for a car using gasoline.

Vis – Komiža road*	Calculation
Consumption, car (passenger) Gasoline	consumption x distance x 2 = fuel (kg) 52.5 x 10 x 2 = 1.05
Emissions and valorization SOx NOx PM10 PM2.5 CO2 Total	emission factor x consumption x unit price x no. vehicles = external cost (€) 0.001 x 1.05 x 12.32 x 21,694 = 0.28 3.512 x 1.05 x 15.15 x 21,694 = 1,211.98 0.041 x 1.05 x 5.06 x 21,694 = 4.73 0.041 x 1.05 x 31.65 x 21,694 = 29.56 3,130 x 1.05 x 0.09 x 21,694 = 6,416.76 7,663.31 €

**distance 10 km, consumption 52.5 g/km*

Table 8.
Calculation of external costs on the route Vis-Komiža for a truck using Euro diesel.

Vis – Komiža road*	Calculation
Consumption, truck (HDV) Eurodiesel	SFOC x engine power x time x 2 = fuel (kg) 157.5 x 200 x 0.2 x 2 = 12.6
Emissions and valorization SOx NOx PM10 PM2.5 CO2 Total	emission factor x consumption x unit price x vehicles no. = external cost (€) 0.015 x 12.6 x 12.32 x 21,694 = 50.51 12.245 x 12.6 x 15.15 x 21,694 =50,708.6 0.203 x 12.6 x 5.06 x 21,694 = 280.77 0.192 x 12.6 x 31.65 x 21,694 = 1,661.06 3,170 x 12.6 x 0.09 x 21,694 = 77,985.16 130,686.1 €

**distance 10 km, speed 50 km/h, time 0.2 h, load 75 %, SFOC 157.5 g/kWh, engine power 200 kW*

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The range of value of external costs on the alternative traffic routes varies from 7,663.31 € per year in road traffic of passenger cars using gasoline to 359,916.48 € per year in maritime ferry traffic if MDO is used. Actually, they are at least 2.4 times higher on the targeted sea route than on the alternative road route. Fuel change from MDO to Euro diesel reduces external costs by 13 % on this ferry line.

5. DISCUSSION AND CONCLUSIONS

The results of the research unambiguously point to road traffic as ecologically more acceptable on the investigated traffic route. This result is significantly affected by the absence of congestion and traffic accidents on this sparsely inhabited Adriatic island. This confirms the need to test the local traffic features on all traffic routes when calculating the external costs. Despite the benefit of the island's ferry connection and the existing port infrastructure in Komiža, the internalization of external costs wouldr represent a significant expense for the local community. This result is confirmed by the study (Martinez de Osez, 2008), pointing out that there are no savings in external costs on their investigated maritime lines in relation to road routes but that, nevertheless, there should be a continuation of public incentives to maritime traffic for better ecological performances in relation to road traffic. The increase in road traffic would certainly have had an impact on the conclusions of this research; however it is difficult to expect it due to a continuous decline in population. It is important to mention the use of Euro diesel fuel in ferries of the national liner (Jadrolinija, 2016), which has significantly reduced the external costs of the investigated maritime line but still not enough to be ecologically competitive to the road route. The research (Vukić et al., 2018) has already indicated the implementation of advanced emission reduction solutions to be the slowest in maritime traffic and currently there are no significant differences among road, rail, and maritime traffic as far as climate change external costs are concerned. This research points out the sensitivity of introducing external costs as a competitive factor on the traffic route. The perspective of the future research should be related to the possibility of introduction of alternative fuels that could change the current relations on the specific traffic route.

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Mission Statements in Port Authorities: Empirical Analysis of Content in Spanish Port System

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Introduction: A structured Strategic Planning process has been developed in the Spanish Port System since 1990s. One of the first elements of this process is the formulation of the mission statement of each Port Authority.

Aim: An in-depth review of the mission statements of the Spanish Port Authorities is carried out in this research, and mission statements are assessed from a theoretical point of view. The goal of the study is to discuss how mission statements of these entities are aligned with the international standards.

Methods: Mission statements are captured from public sources. Two criteria are used for the assessment: its content (analyzing if the mission statement reflects nine key elements usually considered internationally), and its length (number of words). As the first component is qualitative, a Delphi method was used in the assessment of this element.

Results: The mission statements of these Port Authorities reflect more frequently than the benchmark comparison made by over 50 companies seven of the nine key elements. The only two fields in which Spanish Port Authorities show a negative gap are those related to "technology" and "concern of employees". In terms of length, the average of 32 words is shorter than the 50-100 words recommended by some authors.

Conclusions: The Strategic Planning in the Spanish Port Authorities is a long and well -structured process. Port Authorities are essentially market-oriented public organisms and their mission statements seems to be properly formulated following business practices in terms of their content.

KEY WORDS

~ Mission statement
~ Strategic plan
~ Port authority
~ Corporate identity
~ Port system
~ Content analysis

1. Introduction

"*Organismo Público Puertos del Estado*" (OPPE) is the Spanish Governmental Agency dependent on the Ministry for Development (formerly Ministry of Transport and Public Works) responsible for implementing the national Government's port policy in Spain. It also coordinates 28 Port Authorities (PA's) within Spanish territory. These PA's manage a total of 46 major ports. These are considered so-called "ports of general interest" (PGI's) of the Spanish Port System (SPS). Apart from these PGI's, other minor ports are controlled by different administrative entities dependent on different regional governments.

Article 52 of the Spanish State Ports and Merchant Marine Act (SPMA) (Royal Decree-Law 2/2011) lays out that according to the Government's economic and transport policy, the Ministry of Development will approve the model of strategic development, criteria of action as well as general objectives for the technical, economic, financial, and human resource management of the entire group of PGI's of SPS under the administrative umbrella of OPPE.

To this end, OPPE jointly with PA's will elaborate the Spanish Port Strategic Framework (SPSF), which will be ratified by the Board of OPPE and sent to the Ministry of Development for approval.

Additionally, Article 53 of SPMA states that in order to establish the development model and the strategic position of each Port Authority (PA), they may elaborate a Strategic Plan

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covering the ports of its competence, which should include at least: i) an analysis and diagnosis of the current situation, ii) the definition of their objectives and strategic lines, iii) their criteria of act and action plan.

This legal provision is in reality a recommendation and in no case an obligation. However, it is not a new determination since it also had appeared with exactly the same wording in Article 37 of Law 48/2003 which preceded the current SPMA, and it further developed the former previous State Ports and Merchant Marine Act dated 1992 (Law 67/1992).

Enríquez (1993) introduced Strategic Planning in the agenda of SPS with a practical implementation in Valencia PA, and OPPE approved in 1998 the first SPSF which was intended to be the basic common ground for the development of SPS from the strategic standpoint (Puertos del Estado, 2001).

As a result of all this legal and administrative background, most of the 28 PA's have elaborated their strategic plans, adopting international business practices and standards. Additionally, all of them: i) have drawn a Strategic Map (aligned with the strategic lines of SPSF), ii) have successfully implemented the Balance Scored Card following the requirement of OPPE, iii) a performance measurement software has been applied in the strategy planning process (SPP) (Estrada, 2007; Aparisi et al., 2009).

Recently, PA's started to make public its annual Sustainability and Corporate Social Responsibility Reports in which a specific section is dedicated to tackle SPP. In these annual reports, PA's reveal their mission statements (MS) as well as its vision and corporate values.

2. Material and methods: literature review

MS's are primarily based on the guidelines provided by Drucker (1974, 61) who was its pioneer proponent focusing on the relevance of a proper formulation of this first step in SPP.

King and Cleland (1979, 88) recommend organizations to write their MS to: i) make sure all employees and managers understand the firm's purpose or reason for being; ii) provide a basis for prioritization of key internal and external factors utilized to formulate feasible strategies; iii) provide a basis for the allocation of resources; and iv) provide a basis for organizing work, departments, activities, and segments around a common purpose.

Although MS's started to be explicitly formulated from early 1980s (Pearce, 1982; Pearce and David, 1987) and there is a general consensus about the importance of its proper formulation, researchers have paid poor attention to deeply analyze the issue from the theoretical point of view (Sashittal and Tankersley, 1997; Amato and Amato, 2002; David et al., 2014; Alegre et al., 2018).

Pearce (1982) defined the company mission as "*a broadly defined but enduring statement of purpose that distinguishes a business from other firms of its type and identifies the scope of its operations in product and market terms*." Similarly, other authors have defined MS as a written formal declaration that communicates the purpose of an organization (Bart and Hupfer, 2004; Macedo et al., 2016) and "the reason for being" of an organization (Pearce and David 1987; Campbell and Yeung 1991; David et al., 2014).

This first author provided a practical framework to be used in defining an adequate company mission, including recommendations for its content and a process of taking into consideration diverse, if not conflicting, demands placed on strategic direction. This work focused particularly on the social responsibility and its impact on MS.

Other authors have provided guidelines for developing the most appropriate MS. For instance, Lundberg (1984) described the Zero-in technique as a "*structured group process which efficiently develops a consensual synthesized mission statement resulting in high commitment*." Simplifying, this methodology is to make all key managers with major responsibilities within the company or corporation work together in a series of meeting and related activities in order to develop MS.

Developing a proper MS has been acknowledged to be as the very first step in any SPP (Pearce and David, 1987), and it is recognized as a powerful tool for formulating and implementing the organization's strategy if it is properly developed with the involvement of the top management group (Baetz and Bart, 1996).

First Pearce (1982) and later Pearce and David (1987) pointed out that the MS should be the most visible and public part of a strategic plan and suggested a guide for developing the most appropriate statements focusing on eight key elements:

- Customers and/or markets
- Products and/or services
- Core technologies
- Geographic domain
- Expression of commitment to survival, growth, and profitability
- Key elements in the company philosophy
- Company self-concept (distinctive competence)
- Firm's desired public image

These authors developed an empirical investigation to assess the relationship between: i) MS of a company, ii) inclusion of the eight key elements listed above, iii) corporate financial performance of these companies.

They carried out an intensive survey covering 500 companies among which 218 companies replied to the survey (44 %), while 282 companies did not send any response (56 %). The companies that replied to the survey, 40 % of them (88 out of 218) did not have a proper MS, while 5 % replied rejecting to send MS on the basis of confidentiality (11 out of 282). The remaining 27 % (58 companies) did not provide a material that the authors could use consistently, and only 28 % (61 companies) were companies with sufficient and clear information to be included in the study.

Throughout the examination of these 61 companies, the authors reached the conclusion that although it is clear that many variables will affect organizational performance, it is not unreasonable to demand empirical evidence of the presumed integral role of MS in linking SPP with corporate finance.

Further, David (1989) introduced a ninth key element to be included in the assessment, which is "concern for employees". This list of nine topics in MS has later been followed by many authors (Baetz and Bart, 1996; O'Goman and Doran 1999; Rajasekar, 2013; Alegre et al., 2018).

From the economic point of view, the topic of the content of MS and companies' financial performance has been revisited by many other authors as Germain and Cooper (1990), Kaplan and Norton (1992), Medley (1992), Rarick and Vitton (1995), Baetz and Kenneth (1998), Bart and Baetz (1998), Bart et al. (2001), Amato and Amato (2002), Green and Medlin (2003), Atrill et al. (2005), Bartkus et al. (2006), Palmer and Short (2008), Hirota et al. (2010), Desmidt et al. (2011), Genç (2012), Pradeep et al. (2012), Macedo et al. (2016).

Capon et al. (1990) further studied factors affecting the financial performance of companies. They carried out a meta-analysis covering 320 empirical studies covering the period 1921-1987, and they took into consideration environmental, organizational as well as strategic factors (as those included in MS).

As the goal of this work is concerned: i) The American Association of Port Authorities had published a pioneer guideline for the development of SPP in the maritime industry (APPA, 1998), ii) in the context of a work focused in SPP in PA's, the United Nations Conference on Trade and Development (UNCTAD) had paid attention to the different levels of the planning process in port management, and it had identified short and long term processes UNCTAD (1993). UNCTAD highlighted that MS, vision and corporate values are key elements to be formally adopted with long term perspective.

More simplistically than other authors, Bart (1997) states that MS should have three components: i) key market (or target audience), ii) contribution of the product or service, and iii) distinction of the company.

Campbell (1997) considers that MS became an obligatory part of a company's portfolio of literature along with a statement on environmental policy and a commercial brochure selling the company.

Leuthesser and Kohli (1997) state that MS can provide a consistent message about all facets of a firm to the various public concerned and more broadly define the corporate entity as the way in which an organization reveals its philosophy and strategy through communication, behavior, and symbolism.

The need of the involvement of top management in the definition and implementation of MS has been further addressed by Mullane (2002). This author states that the approach that managers take regarding MS formulation is a key issue, and he differentiated the managers according to their loyalty to MS. The author points out that while "*some managers swear by their mission statement*", others "*swear at theirs*". There are managers that understand MS usefulness and they use it to influence the inner working, while others take a passive approach expecting that MS "magically" transform the organizational behavior. In this paper, the author provides recommendations to harness the benefits of their MS.

Stallworth (2008) continued the studies of previous authors by analyzing the content of MS of Fortune 1000 higher-performing and lower-performing firms. The researcher reached the conclusion that the higher-performing firms included eight of the nine recommended components more often than the lower-performing firms did, and the differences were significant for three of those components. Additionally, the author used textual analysis methods. The work identified strategies employed by these firms to create a strong identity (internal ethos) and image (external ethos). The two groups used similar strategies for building corporate identities and images, but they differed in the values they emphasized and the goodwill recipients they targeted.

Desmidt and Prinzie (2009) tackled with the real value of MS by carrying out an explorative analysis of their effectiveness. These authors put the emphasis on the communication perspective.

Powers (2012) provided guidelines for writing organizational MS, and a framework was presented to check where MS fits into the SPP.

In terms of the origin and perspective in its formulation, different authors offered different approaches. For instance, while Lundberg (1984), Baetz and Bart (1996), and Mullane (2002) prefer a manager-focused perspective focusing on the relevance of the managers as originators of MS, David (1989) and Orhan et al. (2014) prefer an employee-perspective approach in which MS is a key element for ensuring employees' alignment with the companies' goals and essence. More recently, David et al. (2014) have investigated from a marketing-oriented approach how a customer-focused perspective is convenient when MS is formulated.

David et al. (2014) highlight that MS should be: i) informative, ii) inspiring, iii) enduring, iv) concise, v) clear, and vi) conducive to both employees and customers forming an emotional bond with the firm.

In a similar way, Gaebler (2018) provides recommendations

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for the development of MS. This author emphasizes five common mistakes in its formulation: i) too long, ii) too boring, iii) too unbelievable, iv) too confusing, and v) too disingenuous.

Additionally, Quain (2018) reveals nine main characteristics that any MS should comply with: i) be short, ii) be unique to your business, iii) create expectations, iv) be realistic, v) be memorable, vi) be active, vii) be positive, viii) be adaptable, and ix) be targeted.

Finally, Alegre et al. (2018) stated that MS is a widely used strategic tool that emphasizes an organization's uniqueness and identity, and there is a general consensus on the need for explicitly formulating MS in organizations.

These authors selected and analyzed 53 articles developing a bibliometric and content analysis regarding MS. According to their perspective, the works selected were grouped into four thematic areas: i) MS development, ii) MS components, iii) MS impact on employees, and iv) MS impact on performance. The overreaching conclusion of this work is that MS's are widely used in practice, but poorly researched in theory. Most articles adopt a managerial phenomenon-based strand, lacking a deep theoretical foundation. The article ends with suggestions for further research in terms of theory, practice, and methodology on this topic.

To the best of our knowledge, there isn't any research focused on the formulation of MS in PA's.

3. DATA

In the context of the current work, a survey has been carried out covering the entire SPS. As a result of this research, it has been found that 86 % (24 out of 28) of the Spanish Port Authorities (SPA) have made public their MS's, while the remaining 14 % either keep it confidential or they had not formally elaborated it. A translation of all these MS's is provided as supplementary material.

4. THEORY, CALCULATION AND METHODOLOGY

MS's differ in four key elements: length, content, format, and specificity (Kemp and Dwyer, 2003; Palmer and Short, 2008; Smith et al., 2001).

In this work the two first key elements (length and content) have been used to assess the MS's of the SPA.

4.1. Criterion 1 - Length Of Ms

As described above, an ideal MS should meet certain criteria (to be unique, create expectations, be memorable, etc.) and include certain items (references to markets, services, self-concept, etc.), which requires a minimum length. The shorter an MS is, the more difficult it is to meet all of the criteria and items.

On the other hand, other authors cited above emphasized the need of avoiding a too boring formulation of MS, and they recommend to formulate it in short and understandable terms.

It seems to be a typical "two sides of the coin view" paradigm. This topic has been addressed by several authors who have concentrated their efforts in determining what the most appropriate length of MS should be.

While some practitioners recommend short statements (Quain, 2018), others simply recommend that it has to be long enough (Clearlogic, 2018).

Some researchers suggest that MS is most effective when it is approximately 100 words in length, avoiding the inclusion of monetary amounts, numbers, percentages, ratios, or objectives (David and David, 2003; Davies and Glaister, 1997; Kemp and Dwyer, 2003).

Clearlogic (2018) highlights how the length of MS is dependent on the complexity of the organization and its goals. Additionally, those statements that are too long or too short will likely have less impact on employee behavior. If it is too long, "*employees may not read the whole mission, or will have a harder time committing all its goals to memory*", while if it is too short, "*it likely is not detailed enough to describe how employees are expected to accomplish each goal.*" According to this author, based on his inspection of 100 Fortune 500 company MS's, the average length is about 45 words.

The problems related to too long an MS is also addressed by Gaebler (2018) in the following terms: "*When it comes to the length of your mission statement, size definitely matters. If your mission statement is a long, drawn out description of every aspect of your company, no one is going to read it, let alone remember it. Your goal is to craft a mission statement that will make an impact and stick in your readers" minds long after they have turned the page. If your mission statement is too long, that simply isn't going to happen.*"

4.2. Criterion 2 – Content of MS

To analyze the content of MS's, different authors have used the nine attributes test developed by Pearce (1982), Pearce and David (1987) and David (1989).

The methodology used in this work is the one described in Kemp and Dwyer (2003), who followed this test. The authors adapted the research to the PA context. To this purpose, the following questions are made:

- Does MS identify the **customers and markets**?
- Does MS identify the **services**?
- Does MS identify the **core technologies**?
- Does MS specify the **geographic domain**?
- Does MS express PA commitment to **survival, growth, and profitability**?
- Does MS specify the key elements in the **PA philosophy**?
- Does MS identify PA **self-concept (distinctive competence)**?

Table 1.
Analysis of the content of Mission Statements of the Spanish Port System.

PORT AUTHORITY	LENGTH	C&M	P&S	L&M	TEC.	CoS	PHI	SC	CoE	Total	%
A CORUÑA	19	0	1	1	0	0	1	1	0	5	56 %
ALICANTE	-	-	-	-	-	-	-	-	-	-	-
ALMERÍA	33	1	1	0	0	0	1	1	0	5	56 %
AVILÉS	18	1	1	0	0	1	1	0	0	5	56 %
BAHÍA DE ALGECIRAS	27	1	1	0	0	1	1	1	1	7	78 %
BAHÍA DE CÁDIZ	46	1	1	0	0	1	1	1	0	6	67 %
BALEARES	28	0	1	1	0	0	1	1	0	5	56 %
BARCELONA	31	1	1	1	0	0	1	1	0	6	67 %
BILBAO	41	1	1	1	1	1	1	1	0	8	89 %
CARTAGENA	18	1	1	1	0	0	0	0	0	4	44 %
CASTELLÓN	39	1	1	0	0	1	1	1	0	6	67 %
CEUTA	43	1	1	1	0	0	1	1	0	6	67 %
FERROL-SAN CIBRAO	49	1	1	1	0	1	1	1	0	7	78 %
GIJÓN	23	0	1	1	0	0	1	1	0	5	56 %
HUELVA	38	0	1	1	0	0	1	0	0	4	44 %
LAS PALMAS	-	-	-	-	-	-	-	-	-	-	-
MÁLAGA	-	-	-	-	-	-	-	-	-	-	-
MARÍN Y RÍA DE PONTEVEDRA	30	1	1	1	0	0	1	1	0	6	67 %
MELILLA	30	1	1	1	0	0	1	1	0	5	56 %
MOTRIL	29	0	1	1	0	1	1	1	0	5	56 %
PASAIA	43	1	1	1	0	1	1	1	0	7	78 %
SANTA CRUZ DE TENERIFE	20	0	0	0	0	0	1	1	0	3	33 %
SANTANDER	27	1	1	0	0	0	1	1	0	5	56 %
SEVILLA	19	0	1	0	0	0	0	1	0	2	22 %
TARRAGONA	56	1	1	1	0	1	1	1	1	8	89 %
VALENCIA	40	1	1	1	0	1	1	1	0	7	78 %
VIGO	31	1	1	0	0	1	1	1	0	6	67 %
VILAGARCÍA	-	-	-	-	-	-	-	-	-	-	-
TOTAL	778	17	23	15	1	11	22	21	2	-	-
AVERAGE	32.4	71 %	96 %	63 %	4 %	46 %	92 %	88 %	8 %	5.54	62 %

This table shows the length of the Mission Statement of each Port Authority jointly with the number of attributes that are included in it. LEN is the length (words) of the Mission Statement, C&M reflects the attribute "Customer and Market", P&S reflects the attribute "Product and Services", L&M is "Location and Market", TEC means "Technology", CoS means "Concern of Survival", PHI is "Philosophy", SC reflects the attribute "Self-Concept", CoE means "Concern of Employees", Total is the aggregate sum of the attributes reflected in each mission statement and % is the percentage of attributes that are included in the Mission Statement.

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- Does MS identify the PA desired **public image**?
- Are the **employees** considered as a key element in the MS of a PA?

Each of the authors of this work independently recorded whether or not the MS of each PA captured each of the nine components identified above. Value "1" indicates that the MS includes reference to the component analyzed, and value "0" indicates that MS does not refer to this component in the MS of such a PA.

Following this individual assessment, the results were sent to the authors to re-assess their opinions respectively in view of the other authors' opinion. Once re-assessed, a second individual judgement was produced.

In a sort of Delphi Methodology, based on a second judgment, the authors finally met in order to discuss the results provided by each one specifically, those in which there was no possibility to reach an agreement about what the most appropriate descriptor ("1" or "0") was.

As a result of this process, a high consensus was reached among them getting the final assessment for each PA.

The results are compiled in Table 1 in which: i) the last column is the calculation of how many "1" are present in the MS of a PA, ii) the last row indicates how many PA's include such elements in their MS's.

5. RESULTS AND DISCUSSION

5.1. Criterion 1 - Length of MS

The length of the MS of each PA is included in the second column of Table 1. In the case of SPS, the average length of MS in SPS is about 32 words, with a standard deviation of 11 words.

The longest statement is that of Tarragona PA (56 words), while the shortest is the one of Avilés PA (18 words).

These results are not totally aligned with the authors cited above, and the length of 32 words in average is shorter than the 45 words recommended by Clearlogic (2018) or the 100 words length suggested by David and David (2003), Davies and Glaister (1997), Kemp and Dwyer (2003).

5.2. Criterion 2 – Content of MS

Analyzing the components used by PA's when formulating their MS's (Table 2), it has been figured out that the approach taken in SPS is basically customer or service oriented. In fact, 96 % of the PA's explicitly include the product / services they provide in the statement. They are also very active in including their philosophy (92 %) and their concerns in terms of public image and self-concept (88 %). Customer / Markets (71 %), Location / Markets (63 %), and concern for survival (46 %) are other topics that PA's typically use in their MS's. However, only one PA (4 %) cites technology / innovation in its MS, and two of them (8 %) consider employees dimension of the statement (it is not discussed herein whether employees have been actively involved in the formulation of the MS or not, but their concerns have been exclusively cited in the MS as any other element).

Table 2.
Number of mission statements that include each component.

Component	Number	Percent.	Rank
Customer / Markets	17	71 %	5
Product / Services	23	96 %	1
Location / Market	15	63 %	6
Technology	1	4 %	9
Concern for survival	11	46 %	7
Philosophy	22	92 %	2
Self-concept	21	88 %	3
Concern for public image	21	88 %	3
Concern for employees	2	8 %	8

This table shows how many each of the nine attributes of an "ideal" Mission Statement are included in the MS of SPS. The first column ("component") is the attribute, the second one ("number") in the total number of PA in which the attribute is included in its Mission Statement., the third one ("percentage") is the percentage of Port Authorities in which such attribute is included and the fourth "rank" is the ranking (i.e. the attribute with ranking 1 is the one more frequently found in the MS of SPS while the ranking 9 shows the attribute which is rarer in this system.

Considering the number of components included in the MS's (Table 3), it is possible to conclude that 8 % of the PA's only include two of them, while 17 % take four, and 25 % consider six of them. In the highest part of the score, one PA (4 %) covers eight out of nine components, and another PA (4 %) considers seven of them, while two PA's introduce six components. The most frequent case is the one in which a PA uses five components in its MS (eight PA's, which means one third of the total).

Table 3.
Number of components in each of the Port Authorities' mission statements.

Number of Components	Number of Ports	Percentage
9	0	0 %
8	1	4 %
7	1	4 %
6	2	8 %
5	8	33 %
4	6	25 %
3	4	17 %
2	2	8 %
1	0	0 %
0	0	0 %

This table shows the overall number of attributes which are included in the MS. The first column shows the overall number of components included, the second column shows the number of Port Authorities in which the "number of components" of this row is included, and the third column (percentage) is the percentage of Port Authorities that include the referred ·number of components". For instance, there are a total of eight (8) Port Authorities in Spain (33 %) which include five (5) components in their Mission Statement (reference is made to the row number 6 of the Table).

In order to compare the content of the MS of the SPS with other environments, the authors have developed a benchmarking analysis comparing the results with two previous researches.

The first is the analysis that has given rise to this methodology (Pearce and David, 1989), based on a survey of 61 MS's, and the second is the one developed by Dharmadasa et al. (2012), who carried out an analysis of 90 out of the 231 companies listed on the Colombo Security Exchange (CSE) of Sri Lanka (Table 4).

Three main conclusions can be highlighted:

First: MS's of the SPA reflect more frequently seven of the nine key elements than those 150 companies' analyses by Pearce and David (1989) and Dharmadasa et al. (2012). Only "technology" and "concern of employees" are the items in which SPA as a group develops poorer MS.

Second: The ranking of items covered by SPA is relatively similar to the ranking showed by high-performance firms in Pearce and Davis (1987). Three out of the first four topics in both cases are "philosophy", "self-concept", and "concern for public image".

Third: "Product / services" is the main topic covered by SPA and low performance firms and it is also the third element in the study carried out by Dharmadasa et al. (2012). However, it only reached number seven in the ranking provided by the high performance firms in Pearce and Davis (1987).

Another finding of this research is the relationship between the length of the MS and the number of these 9 components. Although the statically fit is not relevant (r2 = 0.52), there is some evidence that the longer the statement, the more components it includes. This is something that seems to be intuitive, but has been checked in order to verify if any of the studied PA's has made a long MS omitting several key elements or any PA has been able to capture many of them in a short MS. Simplifying things, those PA's with MS's below 25 words meet no more than 2-5 components, while those with more than 40 words always cover 6-8 elements and in an intermediate group between 25 and 50 words range between 4 and seven components (Figure 1).

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Table 4.
Benchmark Mission Statement Content.

			Pearce and David (1989)					
	PORT AUTHORITIES		**HIGH PERFORMANCE FIRMS**		**LOW PERFORMANCE FIRMS**		**Dharmadasa et al. (2012)**	
Component	**%.**	**Rank**	**%**	**Rank**	**%**	**Rank**	**%**	**Rank**
Customer / Markets	71 %	5	47 %	6	60 %	4	34 %	5
Product / Services	96 %	1	58 %	5	87 %	1	53 %	3
Location / Market	63 %	6	42 %	7	33 %	7	15 %	8
Technology	4 %	9	16 %	8	7 %	8	14 %	9
Concern for survival	46 %	7	95 %	2	87 %	1	57 %	2
Philosophy	92 %	2	89 %	3	60 %	4	43 %	4
Self-concept	88 %	3	89 %	3	53 %	6	60 %	1
Concern for public image	88 %	3	100 %	1	73 %	3	29 %	7
Concern for employees	8 %	8	N/A	N/A	N/A	N/A	37 %	6

This table shows how often each of the key attributes of the MS are included in Port Authorities and how these percentages compare with other sectors, taking into consideration the works of Pearce and David (1989) and Dharmadasa et al. (2012). The first column ("component") is the key attribute, the second and third columns show the percentage and ranking within the Spanish Port Authorities. The fourth and fifth columns reflect the same concepts (percentage and ranking) in a selected group of High Performance firms included in Pearce and David (1989). The sixth and seventh columns are connected with same work but considering low performance firms. The last two columns are the outcome of Dharmadasa et al. (2012) studies.

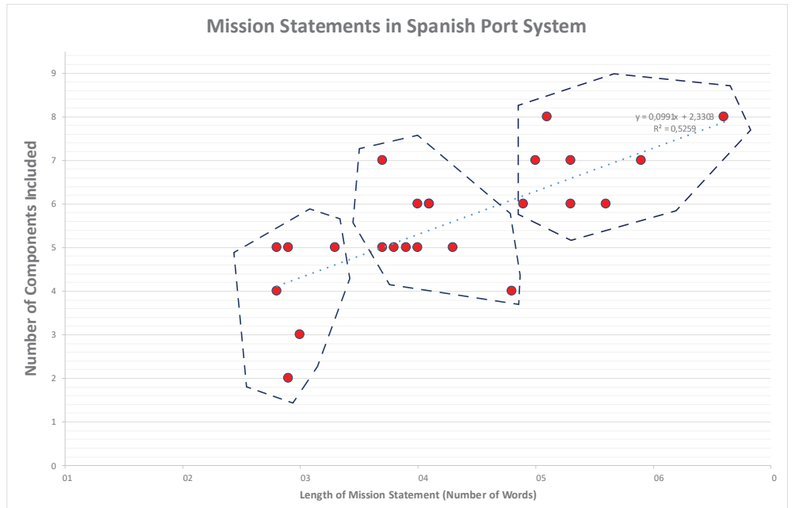

Figure 1.
Length and number of the components addressed in MS.
The figure shows the relationship between the length of the MS and the number of key attributes. Three main groups of Port Authorities can be found with short Missions (less than 25 words), medium length Missions (25-40 words) and long Missions (more than 40 words). Those with more words also include more key attributes (more than six), while those with shorter Statements include typically less than five.

The final conclusion of this research is related to the semantic content of the statement (Table 5). The most used word / concept in the MS's is "port" with 26 occurrences, followed by "service(s)" with 20 occurrences, "development" with 12, and "economic" with 10. Far from this area [hinterland] is used 9 times, [add] value 8 times; "sustainable", "infrastructures", and "competitiveness" 7 times each and, finally, "influence" with 6 repetitions.

Table 5.
Semantic Analysis of Mission Statements.

Word	**Occurrences**	**Frequency**	**Rank**
Port	26	5.8 %	1
Service(s)	20	4.5 %	2
Development	12	2.7 %	3
Economic	10	2.2 %	4
Area [hinterland]	9	2.0 %	5
[add] Value	8	1.8 %	6
Sustainable	7	1.6 %	7
Infrastructures	7	1.6 %	7
Competitiveness	7	1.6 %	8
Influence	6	1.4 %	9

The table shows a semantic analysis of the MS of the Spanish Port Authorities. The key words are included in the first column ("word") jointly with the occurrence in the number of times that this word is included (column 2 - "occurrences"), and the" frequency" (column 3) of this word and its ranking (relative position being ranking 1- the most frequent word in the MS analyzed).

6. CONCLUSION AND FUTURE RESEARCHES

The SPS has developed an administrative and legal well-structured SPP. As early as the 1990s, most of the PA's developed their own Strategic Plan and made public their mission and vision statement as well as their corporate values.

The MS of the SPA's are essentially market-oriented and they are well structured considering business practices in terms of their content. In fact, MS's formulated by SPA reflect more frequently than the benchmark comparison seven of the nine key elements.

The only two fields in which SPA's show a negative gap are those related to "technology" and "concern of employees". An in-depth study of the reasons for this deviation is of potential interest for future researchers.

In terms of the length of the statements, the average of 32 words of the SPS is shorter than the 50-100 words recommended by some authors as a general rule of thumb. An additional comparison with PA's of other countries is another potential area of interest in order to determine if this is a particularity of the SPS or there is a structurally justified reason for this which is applicable to these types of companies.

This work does not discuss the relationship between port performance (financial, operational, environmental, etc.) and the MS of each PA. It is another limitation of the study and it provides and interesting direction for further and future research. For instance, it is not the goal of this work to assess if port size impacts the formulation of the MS or if there is any similarity in the MS's of the PA's if port competitiveness is considered (i.e. if competing PA's develop similar MS's or, at least, they capture the same key elements). This represents a new opportunity for future researchers.

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Model of Forensic Hydrography

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Forensic science plays a vital role in the work of judicial bodies. The contents, knowledge, and specialized expertise permit the identification of facts essential to law enforcement and judicial disputes. Hydrography is an applied science that concerns the physical description, measurement, mapping, and predictions of marine and terrestrial water features (ocean, seas, rivers, lakes, and coastal areas). A variety of economic and other activities take place in water resources. In order to reduce incidents and losses, it is extremely important to operate with accurate hydrographic data. In addition to its standard analytical role, forensics may serve in the prevention of adverse events and /or conditions. This paper aims at contributing towards the development of the new multidisciplinary field of forensic hydrography. The specific objectives are to provide a framework for the establishment of a model of forensic hydrography. A model of forensic hydrography is developed based on eleven modules (elements) relevant to fields in the marine, terrestrial, and coastal water domains. Forensic hydrography should serve the analysis and prevention of unwanted and other events and conditions to increase safety of navigation and security of water resources and in support of all other marine activities, including economic development, defence, safety and security, scientific research, social cohesion, as well as environmental management and conservation.

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~ Water resources
~ Security
~ Forensic hydrography
~ Environment
~ Navigation
~ Infrastructure
~ Artificial intelligence

1. INTRODUCTION

Forensic science plays a vital role in the work of judicial bodies. The contents, knowledge, and specialized expertise permit the identification of facts essential to law enforcement and judicial disputes. Forensic hydrography, as a new discipline of forensic science, has a huge potential in establishing itself as a 'must-have' tool in preserving our planet's most important resources.

Seas, rivers, and lakes are natural resources of the Earth. They occupy about 71 % of the Earth's surface area, whereas continents and islands occupy the remaining 29 %. Therefore, scientific studies of the sea, rivers, and lakes are considered important for humankind. As an applied science, hydrography is one of the sciences that deals with the exploration of the sea, rivers, and lakes (Kasum, Žanić Mikuličić, Kolić, 2018). According to the International Hydrographic Organization – IHO: 'hydrography is the branch of applied sciences which deals with the measurement and description of the physical features of oceans, seas, coastal areas, lakes and rivers, as well as with the prediction of their change over time, for the primary purpose of safety of navigation and in support of all other marine activities, including economic development, security and defence, scientific research, and environmental protection. In addition to supporting safe and efficient navigation of ships, hydrography underpins almost every other activity associated with the sea, including: resource exploitation - fishing, minerals, environmental protection and management, maritime boundary delimitation, national marine spatial data infrastructures, recreational boating, maritime defence and security, tsunami flood and inundation modelling, coastal zone management, tourism and marine science'. Hydrography includes measurements and description of the physical characteristics of the water mass of the oceans, seas, lakes, rivers, and coastal areas. It also deals with predictions of possible changes in the physical characteristics over time in order to improve the safety of navigation. A variety of economic and other activities take place in water resources, such as commercial and non-commercial fisheries or even more environmentally unfriendly activities, like oil and gas exploits. According to the annual report of the European Maritime Safety Agency (2018), the number of losses (financial, technical, fatalities…) and incidents in the maritime industry is steadily growing. Therefore, to reduce some of the losses and incidents, it is extremely important to operate with accurate hydrographic data.

It can be argued that water resources are inextricably linked to diverse human activities defined by the terms: risk, accident, threat, catastrophe, safety, security, navigation, defence, degree of safety, degree of safety protection, degree of safety of navigation, environment, environmental protection, environmental pollution, optimal environmental management, coastal zone management, sustainable fishing, sea exploitation, underwater exploitation, human health, and more. In the maritime and water sector, shipping companies and other business entities play an important role in various business processes. Among other activities, they are involved in the transportation of significant quantities of various cargoes worldwide. Offshore engineering and the exploitation of offshore resources are in constant high dynamic technological development and economic growth. Part of the diverse organizational entities and / or entities of the maritime economy have the characteristics of critical infrastructure. They are exposed to a variety of threats. Accidents occur in the implementation of these activities. For example, in maritime affairs, according to the European Maritime Safety Agency (EMSA), 71 % of maritime accidents occur due to human impact and attributed human error (The European Maritime Safety Agency, 2018). For the most part, these disasters cause consequent pollution of water resources. People in business processes and regulatory environments make decisions based on the available information. The more accurate, reliable and relevant the information, the easier it is to make well-informed decisions and reduce the number of potentially harmful events. Thus, the role of hydrography can be noticed in reducing uncertainty and / or improving the accuracy of information relevant to different processes, for example in the maritime economy (Kasum, Žanić Mikuličić, Kolić, 2018). By utilising hydrographic procedures in the implementation of authorised hydrographic organisations, hydrography provides a sufficient information base in the information part of navigation safety in order to successfully carry out navigation and economic processes at sea and / or at the seabed (Kasum, Gretić, Fredotović Božić, 2010). Therefore, in the area of water resources care, navigation safety, security, defence and management, new methods should be developed to maintain and / or achieve the desired, or sustainable status of water resources.

It is suggested that forensic hydrography could play an important role in this. A basic definition of forensic hydrography is therefore suggested as a multidisciplinary science that uses scientific knowledge and information to determine facts essential to decisions regarding hydrography. Forensic hydrography should serve the analysis and prevention of unwanted and other events and conditions with the purpose of increasing the degree of safety for navigation and security of water resources and in support of all other marine activities, including economic development, security and defence, scientific research, and environmental protection.

This paper aims at contributing to the development of this new multidisciplinary field of forensic hydrography. The specific objectives are to provide a framework for the establishment of model of forensic hydrography and to develop a unique modular system in forensic hydrography.

2. MODEL OF FORENSIC HYDROGRAPHY

A forensic hydrography model was developed with a systematic approach using a general system theory. The system can be considered as a whole, interconnected with a general function. To understand a system, it is crucial to comprehend its subsystems or modules and connections between them. Application of that is found in general system theory (Bertalanffy, 1968). The breakdown into modules and fundamental interfaces presents a general model. The general model of forensic hydrography is shown in Figure 1.

The reasons for the development of forensic hydrography can be assessed by a thorough analysis of the subsystems at the current level of generalization, providing an insight into the processes and / or elements of the contained subsystems.

Forensic hydrography subsystems are related to:

- (P1) safety of navigation and security
- (P2) analysis of conditions and prevention in water resources
- (P3) business data infrastructure,
- (P4) environmental protection of water resources,
- (P5) environmental management,
- (P6) coastal zone management,
- (P7) offshore engineering, water resources, and fishing,
- (P8) public health,
- (P9) critical infrastructures and water resources,

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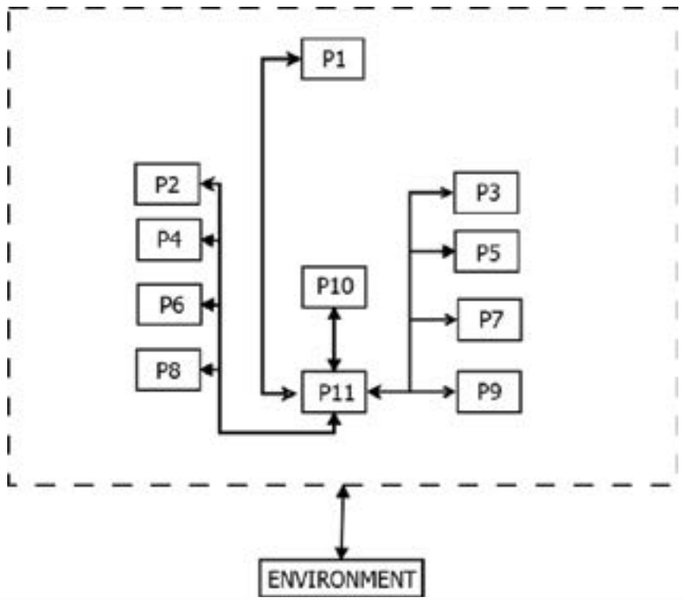

Figure 1.
Forensic hydrography model.

• (P10) e-navigation and new elements of system development and
• (P11) hydrographic cadastre.

(P1) Safety of navigation and security

Navigation safety and security are largely related to critical infrastructures. Therefore, additional attention is required in their implementation. According to legislation in the Republic of Croatia - EU, the safety of navigation enables the fulfilment of the basic conditions regarding maritime facilities, inland navigation vessels, and territorial seas of the Republic of Croatia, its ports, crews, waterways, navigation process, and pilotage service at sea. In order to satisfy the basic conditions regarding the safety of navigation in the Republic of Croatia, 1035 different navigation safety facilities are operational. In the Republic of Croatia, the business entity "Plovput" manages business processes of maintaining maritime facilities and its headquarters is in Split (Ministry of the sea, transportation and infrastructure of the Republic of Croatia, 2019). It is also necessary to emphasise the importance of the Hydrographic Institute of the Republic of Croatia as a public institution for conducting the hydrographic activity of interest to the Republic of Croatia, operating under the Act of Croatian hydrographic activity. By following the legislation, protection in navigation processes refers to merchant ships and ports open to international traffic. Thus, the legislation regulates the security protection of merchant ships of Croatian nationality and the obligations of various state administration bodies involved in navigation and other processes in connection with maritime economy. The obligations of port authorities, various companies, legal and natural persons have been defined. Special purpose ports also specify the obligations of the concession holder. Port and ship security measures have been developed, as well as models for dealing with security threats (Law on the Safety of Maritime Ships and Ports of Republic of Croatia, 2004). Certainly, a complete transport system, including maritime and water transport, is a critical infrastructure (Law on critical infrastructures, 2013). It can be concluded that in the safety of navigation and protection in all the processes of control, measurement, management, etc., crucial information is the one regarding Maritime Safety Information (MSI). What can be improved partly lies in the domain of forensic hydrography with its insights based on the information gathered, assisted in forensic research in connection with the analysis or prevention of adverse events through a forensic approach. Thus, forensic hydrography serves to significantly increase the degree of safety of navigation and protection of water resources through the methods and tools of forensics.

(P2) Analysis of conditions and protection in water resources

In today's scientific and other research, an interdisciplinary, multidisciplinary and transdisciplinary approach is increasingly applied. Natural and other disasters, accidents, adverse events, and catastrophic pollution, particularly of water resources, unfortunately occur on an almost daily basis. The knowledge of particular scientific fields is being increasingly used in interdisciplinary, multidisciplinary, and transdisciplinary research. Forensic hydrography is fundamentally interdisciplinary, multidisciplinary, and transdisciplinary, and it is considered to be justified to use it in process analysis and prevention of adverse events in connection with water resources. For example, petroleum pollution in the Gulf of Mexico that caused great concern within neighbouring countries of Mexico (Botello, Villanueva, Diaz, 1997), as one of the biggest pollution of water resources ever, is presumed to have been avoidedable via early detection in real-time using sensors and its dedicated software.

(P3) - Business data infrastructure

The concept of Spatial Data Infrastructure (SDI) refers to different arrangements and agreements between various governmental and other bodies. In order to facilitate the availability of spatial data in SDI, various policies and technological bases can be included as a system, such as exchange of data, use of databases, etc. As a system, SDI enables data recognition. Once the SDI data is identified, it is possible to evaluate it, for example using geodetic information system as a platform for identification and evaluation. Methods of applying SDI in administrative and other government bodies, science, profession, and economy are also determined (Spatial Data Infrastructure Cookbook v2.0, 2004). Therefore, in enriching the content of SDI, forensic hydrography assumes its role, by providing additional information with maximum accuracy (maritime safety information, bathymetric information, hydrographic information). Such information represents the basis for logical analysis and valid conclusions.

(P4) - Environmental protection of water resources

Life on Earth has become more and more endangered in the last few decades compared to historic trends due to anthropogenic impacts. Certainly, the technical and technological development of humanity facilitates the production processes. However, it is resulting in an increased pollution of water resources. Their pollution decreases the quality of life. Various policies and implementation of mitigation measures have to be considered to protect water resources. The purpose of these policies is to safeguard a long-term protection and conservation of natural resources. Minimum efforts are to maintain the current status and reduce further hazards to water resources. Water resources such as the sea, rivers, lakes, glaciers, etc. are exposed to significant and permanent pollution. A systematic approach in as many areas of water resources as possible is required to determine baseline states in order to monitor and improve the current situation. Forensic hydrography certainly finds its application in terms of records, prevention, and analysis (Definiton on environmental protection).

In terms of environmental protection of water resources, forensic hydrography is tightly linked with the accompanying research fields of forensic hydrology and forensic hydrogeology (Leonhart, Hargis 2005; Ramirez, Herrera 2016; Lischeid, Balla, et.al., 2017; Witte, Zaadnoordijk, Buyse, 2019). Application of these research areas to forensic hydrography can be found primarily in identifying potential pollution sources, tracing pathways, delineation of pollution and protection zones, characterising bio-geochemical reactions, quantification of concentrations and loads of pollution in coastal areas from rivers, with associated impacts on estuarine and marine ecosystems. The second major application is to quantify and mitigate the effects of extreme weather events such as floods and droughts, and their impacts on reshaping coastal and marine landscapes. One of the most interesting land processes is the mobilisation, transport, and deposition of sediments because this affects the hydrography of coastal areas. River sediments can be deposited in river harbours that may result in unwanted siltation of waterways and dredging requirements (Van Schijndel, Kranenburg, 1998). River sediments are often carriers of other forms of pollutants that may impact marine life. Besides, sediment accumulation due to anthropogenic activities on land may cause unnatural impacts, such as the closure of estuaries, modification of ocean/sea currents, and coastal erosion (Wang, Andutta, 2013).

(P5) Environmental management

There are on-going activities in the world to protect the natural environment. As a result, the field of environmental management is developing. Environmental management refers to scientific and professional research related to habitat conservation, hazard control, monitoring, use, and conservation of various natural resources. Scientists and experts from different scientific fields and branches of science are involved in scientific and professional environmental research (Voulvoulis, Burgman, 2019). Besides biophysical sciences, important components of environmental management are the socio-economic and governance regulatory aspects. This is why a multidisciplinary approach is used in environmental management.

One of the basic principles and purposes of environmental management is to provide solutions for sustainable development, growth of the economy and job creation, whilst maintaining and conserving environmental goods and services. In order to achieve this balance, various approaches and strategies can be adopted according to the principles of green or circular economy (Ghisellini, Cialani, Ulgiati, 2016), such as the "polluter-pays principle", trade-offs that may allow development whilst

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providing reasonable environmental protection etc. Decisions that may affect the biophysical environment are ultimately regulated within national and EU frameworks, such as Law on the Safety of Maritime Ships and Ports of the Republic of Croatia and EMSA.

Forensic hydrography, in particular, due to its interdisciplinary, multidisciplinary, and transdisciplinary nature in terms of records, prevention, and analysis, allows for an improvement in the environmental management process, both through the provision of physical data and evidence and through the application of law and regulatory frameworks.

(P6) Coastal zone management

Seas, oceans, and other water surfaces occupy approximately 2/3 of Earth's surface. The land is pervaded and surrounded with water resources and this creates an associated coastline. Therefore, a new area of activity called Coastal Zone Management (CZM) was conceptualized a few decades ago. Amongst the various coastal zone management activities, actions, and processes related to environmental, economic, and human activities are coordinated. The implementation of the CZM seeks to restore, develop, conserve, and protect coastal resources (NOAA's Coastal Zone Management). Therefore, forensic hydrography plays an important role in enabling improved coastal zone management, by directly providing maximum accuracy information, thereby improving the quality of conclusions based on logical forensic analysis, primarily in the prevention of adverse events in contact with land with water resources.

Such adverse events may be caused by droughts, floods or extreme atmospheric events (e.g. cyclones, hurricanes) that result in changes of coastal morphology. Sea level rise, in combination with extreme events, may exacerbate the effects on coastal wetlands and erosion, tidal ranges, human settlements, infrastructure, harbours and seawater pathways (Passeri, et. al., 2015). The frequency and intensity of extreme weather events and sea-level rise are predicted to increase due to climatic changes (IPCC, 2014) and this may result in increased hazards in coastal areas. Forensic hydrography can play an important role in coastal infrastructure, business and property insurance disputes (Koerth, Vafeidis, Hinkel, 2017). Seawater intrusion due to exploitation of groundwater resources and land subsidence is also a hazard in coastal areas where forensic hydrography may be essential (Werner, et.al., 2013; Huang, Ji, 2018). Additional secondary effects that may also require the engagement of forensic hydrography may relate to water supply and availability (volumes and water quality) in coastal areas.

(P7) Offshore engineering, water resources, and fishing

Offshore engineering represents a significant part of the global economy in exploiting natural energy reserves. In economic activity in the water resource, ecological accidents may occur with significant damages to the sea/ocean and coastal ecosystems. It can be argued that humanity's interaction with the sea and with water resources in general, is initially noticeable in fishing. Fishing in seas, oceans, rivers, and lakes may be either a food source or recreational. Due to technical and technological development, fishing is constantly evolving as a form of economic activity. It must be emphasized that over-fishing, as well as non-critical breeding, represent a danger to the survival of certain species of fish and other organisms in the sea and other water resources. In these human economic and sports activities, forensic hydrography certainly finds its place, especially in the analysis of the status and prevention of over-exploitation (Merriam Webster Dictionary, 2019).

(P8) Public health

The position of forensic hydrography in the public health domain can be assessed through a transparent analysis of the concept of health. Health can be considered as the condition of a person without illness or injury. In today's world, difficult, often dramatic events, naturally or artificially induced, are on the rise. These events include, for example fires, floods, wars, poisonings and more. Such events, often due to the mass and variety of consequences, often produce certain effects on human health and they present additional new challenges for the healthcare systems. For prevention, preliminary preparation, as well as subsequent analysis, forensic hydrography plays its role (Definition of health, 2019).

(P9) Critical infrastructures and water resources

Various systems of national importance are considered critical infrastructures. Interruption of their proper operation may result in an interruption of the flow of goods or services. If the interruptions present serious consequences, for example in national security, the environment, human health, human life, property, security, the economic stability of the country, and the continued functioning of the state government, then they become part of a critical infrastructure. The Critical Infrastructures Act regulates national (Law on critical infrastructures, 2013) and European critical infrastructures (Council Directive on the identification and designation of European critical infrastructures and the assessment of the need to improve their protection, 2008). The same law defines sectors of national critical infrastructures. Critical infrastructure management is also determined. For this purpose, risk analysis and security planning are made for critical infrastructures, and a security coordinator is appointed. Critical infrastructures related to marine and water resources are also logically linked to forensic hydrography in the sense of the very definition of forensic hydrography, considering that maritime traffic represents a significant part of protecting critical infrastructures (Law on critical infrastructures, 2013).

(P10) E-navigation and new elements of system development

This subsystem, within the forensic hydrography system model, predicts the future integration of all unlisted or unrecognized elements essential to the sustainability of the system and the generation of expected output sizes, i.e. results, with the support of artificial intelligence. For example, the E-navigation concept of the International Maritime Organization (IMO) may be classified here. Maritime traffic is defined mostly as an act of business of transportation of goods and as such is highly regulated by IMO. Therefore, using a piece of hydrographic information through e-navigation is essential, and maritime traffic cannot be imagined without hydrography. Using multiple information-based platforms means to integrate all available elements to provide safety and sustainability of maritime traffic.

(P11) Hydrographic cadastre

World hydrographic activity is determined by the activities of the International Hydrographic Organization (IHO) based in Monaco. Hydrographic activity at a global level brings together knowledge about the sea and other water resources. The organized hydrographic activity contributes towards the valid collection of the most accurate information related to forensic hydrography (Kasum, Žanić Mikuličić, Kolić, 2018; Kasum, Gretić, Fredotović Božić, 2010; Žanić Mikuličić, Kasum, Jugović, 2017). Based on the systematic analysis performed in this paper, it can be concluded that the information (Fh (1), Fh (2),…,Fh (n)), presented in Table 1, constitutes the information set of forensic hydrography F.

$$F = \{F_{h1}, F_{h2}, \ldots, F_{hn}\} \quad (1)$$

The information presented in Table 1, depending on the degree of confidentiality, can be used to develop a database and/or banks of information and / or data, and to classify, quantify, and evaluate data and information.

With such banks and/or databases it is certainly possible to optimally manage information gathering, synthesise information and use it in the prevention of adverse events, assessments of risks and damages, and dispute settlements.

It is also considered logical that forensic hydrography on its own can be built as a separate subsystem of hydrographic activity at the world level, partly supported by artificial intelligence and systematically classified in the activity of hydrographic cadastre of hydrographic organisations.

Table 1.
Forensic hydrography information and / or data.

F_n [1]	Description
F_{h1}	Analysis of past events
F_{h2}	Results of analysis of past events
F_{h3}	Simulation of events in water resources
F_{h4}	SDI information of maximum accuracy
F_{h5}	Information on existing processes in environmental management
F_{h6}	Data on pollution
F_{h7}	CZM information
F_{h8}	Results of conducted forensic analysis
F_{h9}	Forensic hydrography information
F_{h10}	Maritime cadastre information
F_{h11}	Database and banks of data on all available natural and other catastrophes, accidents, adverse events, and catastrophic pollutions
F_{h12}	Fishing information
F_{h13}	Breeding information within water resources
F_{h14}	Information on the state of water resources
F_{h15}	Health information
F_{h16}	Offshore information
F_{h17}	Prevention processes
F_{h18}	Processes of action
F_{h19}	Information on critical infrastructures
F_{h20}	Bathymetric data
F_{h21}	Hydrographic data
F_{h22}	E-navigation system data
F_{h23}	Entities on bottom of water resources
F_{hn}	Others

3. CONCLUSION

It can be concluded that, in order to conserve the world's water resources, it is extremely important to contribute towards the development and application of forensic hydrography. Any field of science at some point in time can be considered as a part of forensic science. Forensic hydrography can serve as an analysis and prevention of unwanted and other events and conditions

1. *Marking the information and / or data of forensic hydrography.*

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with a view to increasing the degree of safety of navigation and security of water resources. It can also support all other marine activities, including economic development, security, and defence, scientific research, and environmental protection. It is also considered beneficial to integrate forensic hydrography into the regular processes of hydrographic organisations, especially through the activity of the hydrographic cadastre. Of course, the realisation of forensic hydrography depends on recognising it and raising awareness of the threat to water resources globally, developing the necessary computer and software support, and educating experts. Capacity building is especially required in determining the state and transition between system states, guided by general system theory, and developing applicable decision algorithms in the forensic hydrography system, as well as applying artificial intelligence systems.

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Review of Autonomous and Remotely Controlled Ships in Maritime Sector

Karlo Bratić, Ivan Pavić, Srđan Vukša, Ladislav Stazić

This paper presents the extent of the currently achieved progress in autonomous and remotely controlled ships in the maritime sector. Major researches, statements from relevant sources and various anticipations on this subject are presented to outline a comprehensive scope of such progress.

The engine room on conventional merchant ships is used as a viewpoint because it comprises numerous and complex systems. The main purpose of this paper is to establish a link between the levels of autonomy and the engine room with its associated systems on a conventional ship. At each level, the link should describe the relations between autonomy and the systems which are commonly found in the engine room on conventional ships.

To create this link, comparison analysis uses the latest statements from the International Maritime Organization (IMO) and Classification Societies. Technical standards for autonomous and offshore vessels are derived from the guidelines provided by Classification Societies. Technical standards and requirements, related to the engine room of such ships, are individually described and compared to provide accurate and comprehensive scope of their current progress.

KEY WORDS

~ Classification societies
~ Autonomous ships
~ Remotely controlled ships
~ Autonomy levels
~ Engine room

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1. INTRODUCTION

The concept of remotely controlled and autonomous ships reaches back to the 19th century (N. Tesla, 1898) when an idea about autonomy in the maritime traffic was established. This idea is described under the patent named "Method of and apparatus for controlling mechanism of moving vessels or vehicles". While the concept of remotely controlled and autonomous ships may not represent a new concept, the realization of this concept certainly does.

Lately, rapid progress is noted regarding the realization of this concept. Research of various literature reveals numerous reasons for the introduction of this concept into the maritime sector. Impacts that these types of ships will have can only be anticipated. The initial period of exploitation should determine the advantages and disadvantages of their introduction to maritime traffic. They should have the greatest impact on three aspects:

- Financial
- Environment protection
- Safety.

Safety should be of paramount importance. Figure 1 shows that from a total of 880 accidental events analyzed during the investigations, 62 % were attributed to a Human Erroneous Action, which was followed by equipment failure presenting 22 % (EMSA, 2016).

Also, it was noted that the shipboard operations represented the main contributing factor at 71 % of the total accidents. These data lead to the presumption that if human action is less involved in shipboard operations, the likelihood of accident occurrence should be reduced. A study from 2017 supports this presumption (K.Wróbel, J. Matewka, P. Kujala, 2017). This study analyzed 100 accidents that occurred from 1999 to 2015. The goal of this study was to assess the occurrence likelihood of an accident if

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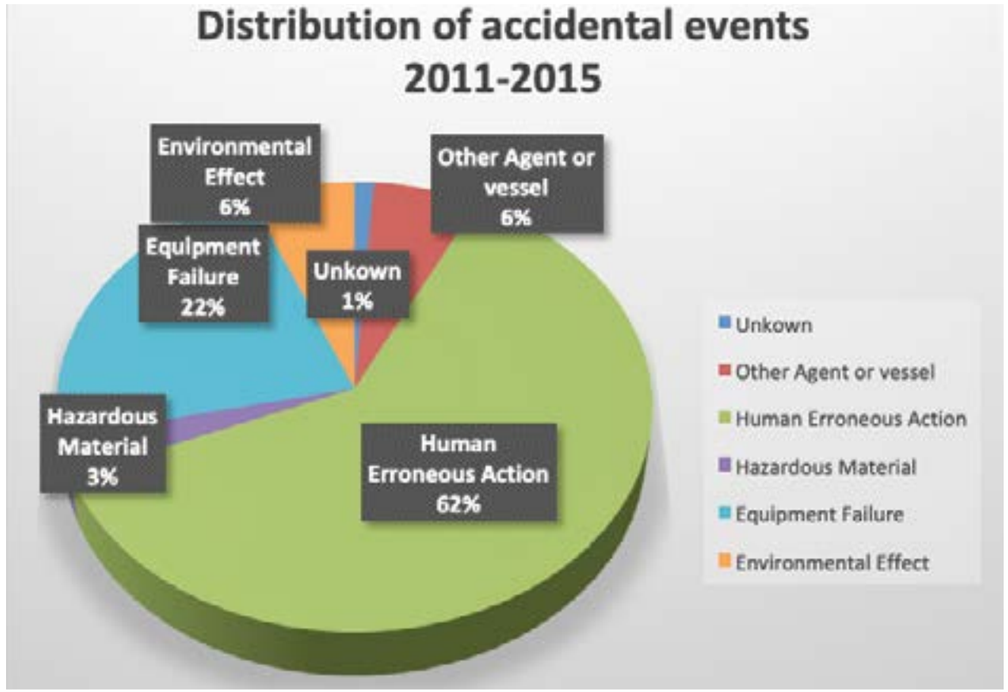

Figure 1.
Distribution of accidental events 2011-2015 (EMSA, 2016).

the vessel had been unmanned. The results showed that the likelihood of grounding and collisions might have significantly decreased, while severe consequences might occur in case of some accidents, such as a fire on board.

Also, a study among ship operators was conducted to determine the technology impact on safety. It is noted that the higher the level of automation and technological processes, the fewer crewmembers are needed. The aim of higher levels of technological processes and automation is to improve the efficiency of the vessel. The result of the study led to the conclusion that changes in work organization on board and technology advancement could add to the occurrence of human error (D. Mišković, T. Bielić, J. Čulin, 2018).

This paper aims to provide a cross-section on the technical standard which Classification Societies have stated regarding the autonomous and remotely controlled ship as well as to relate autonomy levels with the engine room that can be found on such ships and compare this link with the engine room on a conventional ship.

2. PRESENT RESEARCHES (LITERATURE REVIEW)

The terms “unmanned” and “autonomous” ships, while having a different meaning, are often used as synonyms. Therefore, it is essential to describe the terms used. According to Rødseth and Nordahl (2017), the term “autonomous ship” refers to a ship that can perform a set of defined operations without or with reduced supervision by the bridge crew. “Unmanned ship” refers to a ship on which the crew can be on board, but are not present on the bridge for performing or supervision of the ship´s functions. Figure 2 shows the classification of autonomous ship types with the associated terminology.

Maritime Autonomous Surface Ship (MASS) is a provisional term proposed by International Maritime Organization (IMO), and that is the reason why this term can often be used as a general term for referring and defining an autonomous ship. The analysis of terminology provides a basis for a comprehensive approach. In Table 1, the term MASS is additionally classified.

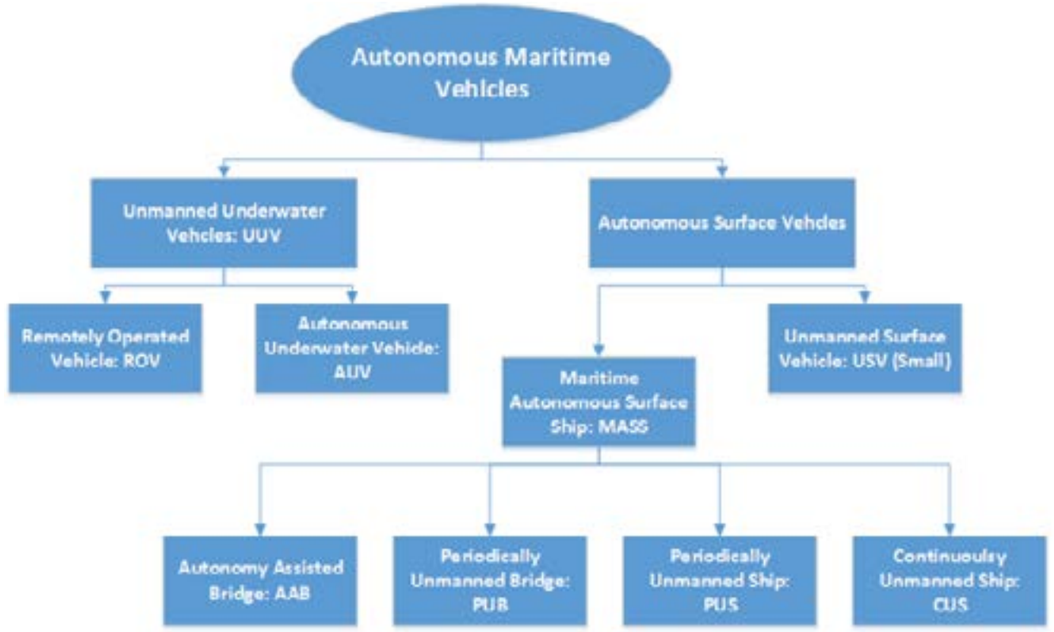

Figure 2.
Classification of autonomous maritime system and autonomous ship types (O.J. Rødseth, H. Nordahl, 2017).

Table 1.
Description of MASS subdivisions.
Source: Made by author, using data from the Definitions for Autonomous Merchant Ships (Rødseth and Nordahl, 2017).

Autonomy Assisted Bridge (AAB)	The ship bridge is always manned and the crew can immediately intervene in ongoing functions.
Periodically Unmanned Bridge (PUB)	The ship can operate without the crew on the bridge for limited periods, e.g. in the open sea and good weather. The crew is on board ship and can be called to the bridge in case of problems.
Periodically Unmanned Ship (PUS)	The ship operates without bridge crew on board for extended periods, e.g. during the deep-sea passage. Occasionally ashore personnel arrives to supervise ship.
Continuously Unmanned Ship (CUS)	The ship is designed for unmanned operation of the bridge at all times, except perhaps during special emergencies.

Also, actual researches and projects are presented to highlight the progress made regarding autonomous ships. “Maritime Unmanned Navigation through Intelligence in Networks” (MUNIN) is a project that lasted for 36 months. It achieved a technical concept for unmanned merchant (cargo) ship. According to Burmeister and Moraeus (2015), “*In a base scenario, the MUNIN bulker is found to improve the expected present value by mUSD 7 over 25 years compared to the reference bulker.*" Equating costs between the concept used in the project and the conventionally manned bulker are established as differences

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between additional investments (initial investments, shore services) and cost savings (crew expenses, fuel efficiency).

"Advanced Autonomous Waterborne Applications Initiative" (AAWA) is a project led by Rolls-Royce that consists of three phases. According to Laurinen (2016), this project "*aims to produce the specification and preliminary designs for the next generation of advanced ship solutions*." (Jokioinen et al, 2016). From this initiative, a collaboration between Rolls-Royce and FinFerries arose and resulted in a research project named "Safer Vessel with Autonomous Navigation" (SVAN). The result of this project was a demonstration of the first fully autonomous ferry named – "Falco" (2018 Rolls-Royce plc, 2018). The demonstration consisted of two voyages. The first voyage was autonomous, where the vessel was able to perform docking operations and avoid obstacles. The second voyage vessel was remotely controlled from Remote Shore Centre (RSC) located 45km away from the vessel.

Furthermore, collaboration between Rolls Royce and Svitzer resulted in the remote operation of a tug boat, *Svitzer Herold*. The operation of the vessel was conducted by the vessel´s captain from a remote land location. During this demonstration, remotely controlled maneuvers such as piloting, turning the vessel, berthing and undocking were safely performed (Maritime Cyprus admin, 2018).

YARA Birkeland is anticipated to be the first completely autonomous ship. Propulsion is intended to be fully electric and designed as an open-top type containership. Also, it is planned to have a capacity of 120 TEU (*twenty-foot equivalent unit*) and be used for commercial purposes. The ship should be free of exhaust gases and ballast waters. To achieve this, the ship is equipped with fully electric propulsion and uses a battery pack as permanent ballast. Ship´s operation is planned in between three ports and within 12 nautical miles from the shore. Figure 3 shows the development and planned operation of *YARA Birkeland*. The autonomy level is planned to be achieved gradually, throughout a few stages. The initial stage anticipates crew on board, the next stage is moving to a remote crew, and the final stage is complete autonomy, which should be achieved over several years.

Comparison between *YARA Birkeland* and a similar-sized conventional ship is used to predict significant cost savings. Such savings are anticipated on the basis that there will be no requirements for fuel or crew. Benefits from using electric propulsion should result in a reduction of greenhouse gas emissions (Kongsberg, 2017).

The project, as mentioned earlier, are not isolated researches regarding autonomous ships, these are some other researches and project developed across the globe (B. Eder, 2018):

- • *Katana* - designed by Israel Aerospace Industries and represents an advanced, multi-purpose, unmanned surface vessel (USV). It is produced for military services, uses dual-mode operation, meaning that it can be used as unmanned or as a crew vessel.

Figure 3.
Development timeline of YARA Birkeland.
(Source: Made by the author, using data of Autonomous ship project, key facts about YARA Birkeland (Kongsberg, 2017).

- Joint research of Shenzhen HiSiBi Boats Company and Harbin Engineering University in China resulted with *Tianxing-1*, an unmanned surface vehicle (USV) primarily made for military operations.
- L3 ASV Company is a UK Company that currently provides surface vessels from 10 to 42 feet with matched control systems, software, and autonomous unmanned systems. Capabilities were time-tested and demonstrated on multiple types and sizes of vessel, throughout 1,500 operating days of service (ASV 2018, 2018)

Lately, in parallel with the accelerated and extended development of autonomous vessels, a need for testing areas arises. This indicates that testing areas are becoming a necessity for the safe introduction of these types of ships into maritime traffic. Current testing areas for autonomous and remotely controlled ships are (International Network for Autonomous ships, 2019):

- *Storfjorden, Horten*, and Trondheim test areas in Norway. The Trondheim fjord came to existence as the world's first test area for vehicles moving below, on and above the water surface and are remotely or autonomously managed.
- *Jaakonmeri* test area is located off the coast of Finland, and it has an additional offer for testing ships under ice conditions.
- *De Vlaamse Waterweg nv* has opened test area in Belgium.
- In 2018, the construction of the *Wanshan Marine Test Field* in China has begun. It is an offshore test field for unmanned surface vehicles (USVs). Upon completion, it will be the largest unmanned marine testing ground in the world.
- In the USA, the Smart Ships Coalition announced that *The Keweenaw Peninsula Waterway area* should be a testbed area for autonomous surface and sub-surface vehicles.

3. IMO AND AUTONOMOUS SHIPS

Highlighted researches and achievement indicate accelerated and continuous progress of autonomous and remotely controlled ships on a global level. Accordingly, that is why implementation, means of regulation, and legislative framework need to be appropriately addressed.

International Maritime Organization (IMO) sets global standards and regulations concerning international shipping. Consequently, IMO has a responsibility to make the introduction of these types of ships to international shipping safe, secure, and environmentally acceptable. In 2018, IMO began to investigate the introduction of autonomous and remotely controlled ships. It was announced that investigation will be conducted via regulatory scoping exercise. To address autonomous and remotely controlled ships, the term Maritime Autonomous Surface Ships (MASS) is proposed for this exercise. For regulatory scoping exercise, MASS is defined as: "A ship which, to a varying degree, can operate independently of human interaction."

After defining what autonomous ship is, the next issue is to define the degrees of autonomy. The degrees of autonomy, as defined by IMO, are set out for mentioned exercise (IMO takes first steps to address autonomous ships, 2018):

- "Degree one: Ship with automated processes and decision support: Seafarers are on board to operate and control shipboard systems and functions. Some operations may be automated and at times be unsupervised but with seafarers on board ready to take control.
- Degree two: Remotely controlled ship with seafarers on board: The ship is controlled and operated from another location. Seafarers are available on board to take control and to operate the shipboard systems and functions.
- Degree three: Remotely controlled ship without seafarers on board: The ship is controlled and operated from another location. There are no seafarers on board.
- Degree four: Fully autonomous ship: The operating system of the ship is able to make decisions and determine actions by itself."

Safety, feasibility, and legislation are the main issues that need to be addressed. To resolve these issues safely, the Maritime Safety Committee (MSC), which is IMO´s technical body, has approved research of MASS. On the 99th session of MSC (Report of the Maritime Safety Committee on its ninety-ninth session, 2018), the framework for researching was endorsed, which will be realized through regulatory scoping exercise. The completion date for this exercise is targeted for 2020. For the exercise, correspondence group and methodology are established, holistic approach is proposed, whereas the extent should cover risks and benefits concerning any aspect of safety. Any MASS definitions and concepts of different types and levels of autonomy, automation, operation, and manning should be provisional. The working orientation of this exercise should be focused on the user, not technology.

The scoping exercise consists of two steps. In the first step, present provisions for IMO´s instruments list need to be recognized. IMO´s instrument list consist of (IMO takes first steps to address autonomous ships, 2018):

- The International Convention for the Safety of Life at Sea – SOLAS.
- The International Regulations for Preventing Collisions at Sea – COLREG.
- The International Convention on Load Lines – CLL.
- The International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers - STCW, and STCW-F – concerning training of fishers.
- Search and Rescue – SAR.
- International Convention on Tonnage Measurement of Ships.
- Convention for Safe Containers – CSC.
- Special trade passenger ship Agreement - STP.

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During this step, the application of these instruments to the MASS needs to be assessed. Additional information about the deployed methods, results, and exact time needed for each step is anticipated for MSC 102 session, scheduled for May 2020. For instruments associated with autonomy degrees and maritime safety, the following is determined:

- Apply to MASS and prevent MASS operations.
- Apply to MASS and do not prevent MASS operations and require no actions.
- Apply to MASS and do not prevent MASS operations, but may need to be amended or clarified, and/or may contain gaps.
- Have no application to MASS operations.

The objective of the next step is to determine the most suitable way of addressing MASS operations. It is achieved by conducting analysis in which the human element, technology, and operational factors are taken into account. The main goals of the analysis are to determine the necessity for (Maritime Safety Committee, 100th session, 2018):

- Equivalences as provided for by instruments or developing interpretations and/or
- Amending existing instruments and/or
- Developing new instruments and/or
- None of the above as a result of the analysis.

Aside from IMO´s statements, during the 99th session of MSC, additional considerations on definitions for levels and concepts of autonomy were suggested. Regarding definitions and levels of autonomy, six suggestions were proposed. Proposals were given by two Classification Societies, two industry/research associations, one company involved in autonomous technologies, and one consultant. In Table 2, four suggestions are shown because all the suggestions given by Classification Societies are examined in a separate table.

In this session, the background was presented to point out the progress that has been marked regarding autonomous ships. It was underlined that a few projects were conducted on autonomous maritime traffic, such as MUNIN and AAWA project, emphasizing the progress achieved in this aspect. Project *One Sea – Autonomous Maritime Ecosystem*, which is a collaboration between shipyards and ship owners, is highlighted as ongoing work on the subject of autonomous maritime traffic. Also, a recently achieved joint point of view regarding levels of autonomy in the automotive industry was mentioned. This achievement outlines potential direction concerning levels of autonomy in shipping (Considerations on definitions for levels and concepts of autonomy, Submitted by Finland, 2018).

Table 2.
Proposals on levels of autonomy presented during MSC´s 99th session.
(Source: Made by the author using data from Considerations on definitions for levels and concepts of autonomy, Submitted by Finland, 2018).

The UK Marine Industries Alliance	
Level of autonomy	**Description**
Level 0 - Manned	Ship/craft is controlled by operators aboard.
Level 1 - Operated	Under Operated control, all cognitive functionality is within the human operator. The operator has direct contact with the unmanned ship over, for example, continuous radio (R/C) and/or cable (e.g. tethered UUVs and ROVs). The operator makes all decisions, directs, and controls all vehicle and mission functions.
Level 2 - Directed	Under Directed control, some degree of reasoning and ability to respond is implemented into the unmanned ship. It may sense the environment, report its state, and suggest one or several actions. It may also suggest possible actions to the operator, such as, for example, prompting the operator for information or decisions. However, the authority to make decisions is with the operator. The unmanned ship will act only if commanded and/or permitted to do so.
Level 3 - Delegated	The unmanned ship is now authorized to execute some functions. It may sense the environment, report its state and define actions, and report its intention. The operator has the option to object to (veto) intentions declared by the unmanned ship during a certain time, after which the unmanned ship will act. The initiative emanates from the unmanned ship and decision-making is shared between the operator and the unmanned ship.
Level 4 - Monitored	The unmanned ship will sense the environment and report its state. The unmanned ship defines actions, decides, acts, and reports its action. The operator may monitor the events.
Level 5 - Autonomous	The unmanned ship will sense the environment, define possible actions, decide, and act. The unmanned ship is afforded a maximum degree of independence and self-determination within the context of the system's capabilities and limitations. Autonomous functions are invoked by the on board systems at occasions decided by the same, without notifying any external units or operators.
The Ramboll	
Level of autonomy	**Description**
M - (Manual)	The operator (master) is on board controlling the ship, which is manned as per current manning standards. Subject to sufficient technical support options and warning systems, the bridge may at times be unmanned with an officer on standby ready to take control and assume the navigational watch.
R - (Remote)	The ship is controlled and operated from shore or another ship, but a person trained for navigational watch and maneuvering of the ship will be on board on standby ready to receive control and assume the navigational watch.
RU - (Remote, unmanned)	The ship is controlled from shore or another ship and does not have any crew on board.
A - (Autonomous)	The operating system of the vessel calculates consequences and risks. The system can make decisions and determine actions. The operator onshore is only involved in decisions if the system fails or prompts for human intervention.
The Norwegian Forum for Autonomous Ships (NFAS)	
Level of autonomy	**Description**
Decision support	Decision support and advice to crew on the bridge, the crew decides.
Automatic bridge	Automated operation, but under continuous supervision by the crew.
Remote ship	Unmanned continuously monitored and direct control from shore.
Automatic ship	Unmanned continuously monitored and direct control from shore.
Constrained autonomous	Unmanned, partly autonomous, supervised by the shore.
Fully autonomous	Unmanned and without supervision.
Rolls-Royce	
Level of autonomy	**Description**
Level - 0 No autonomy	All aspects of operational tasks performed by the human operator, even when enhanced with warning or intervention system. The human operator safely operates the system at all times.
Level 1 - Partial autonomy	The targeted operational tasks performed by the human operator but can transfer control of specific sub-tasks to the system. The human operator has overall control of the system and safely operates the system at all times.
Level 2 - Conditional autonomy	The targeted operational tasks performed by an automated system without human interaction and the human operator performs the remaining tasks. The human operator is responsible for its safe operation.
Level 3 - High autonomy	The targeted operational tasks performed by an automated system without human interaction and the human operator performs the remaining tasks. The system is responsible for its safe operation.
Level 4 - Full autonomy	All operational tasks performed by an automated system under all defined conditions.

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In addition, it was noticed how suggested levels of autonomy varied numerously as well as in their definitions. During this session, definite number or definitions were not achieved, but it was noted that levels of autonomy should be comprehensive, applicable to real projects, and numerously minimalized if possible.

4. CLASSIFICATION SOCIETIES AND AUTONOMOUS SHIPS

As mentioned, IMO has already started to identify the safety, security, and environmental aspects of MASS operations in line with the existing IMO standards. In parallel with MASS introduction, the need for a new and possibly additional level of technical requirements arose. The International Association of Classification Societies (IACS) aims to contribute to this subject by designing requirements and processes for identified emerging areas and gaps (Position paper MASS, 2019). IACS included this MASS agenda on its strategic Action Plan:

- Review of all IACS Resolutions and Recommendations to recognize possible requirements that might obscure technical development of MASS.
- Address possible issues that might obscure the technical development of MASS.
- Also, IACS has conducted several initiatives on this matter, such as:
- Internal review of all Resolutions (2017)
- Pilot project for selected IACS Resolutions (2018)
- Basic Principles for drafting New and revised IACS Resolutions (2018)
- Establishment of IACS Task Force on MASS (2019)
- References to IACS' Leadership or Participation in external Meetings/Activities

According to Musonov (2018), shifting from ships with personnel to autonomous ships will evolve gradually. It is hardly realistic to expect that fully autonomous vessels commence worldwide operation in a short period, such as several years. Shifting should be perceived as a step-by-step process in which the phased implementation of various technologies is observed. As the main technical advisor to IMO, IACS intends to contribute in future work by:

- Continuing its participation in the IMO Working Group at MSC 101 (June 2019) and MSC 102 (May 2020) as well as at scheduled Intersessional MSC Working Group on MASS (September 2019).
- Monitoring the development of Guidelines on MASS trials initiated by MSC 100, and providing comment as necessary.
- IACS intends to continue its active participation in IMO regulatory scoping exercise on MASS (February 2019 – February 2020).
- IACS plans to monitor ISO/TC8/WG10's work program on the development of new ISO standards related to MASS terminology and concepts for ship autonomy.

Figure 4.
International regulations and technical standards for autonomous ships (Source: Made by the author, using data Guidelines for Autonomous Shipping (2017), LR Code for Unmanned Marine Systems (2017), Autonomous and remotely operated ships (2018), Guidelines for autonomous cargo ships (2018).

Table 3.
Autonomy levels, according to Classification Societies.
(Source: Made by the author using data of Guidelines for Autonomous Shipping (2017), LR Code for Unmanned Marine Systems (2017), Autonomous and remotely operated ships (2018), Guidelines for autonomous cargo ships (2018).

Bureau Veritas						
Level of autonomy		**Definition**	**Acquisition**	**Analysis**	**Decision**	**Action**
0	Human operated	Human makes all decisions and controls all functions.	System Human	Human	Human	Human
1	Human directed	System suggests actions Human makes decisions and actions.	System	System Human	Human	Human
2	Human delegated	System invokes functions Human can reject decisions during a certain time.	System	System	System Human	Human
3	Human supervised	System invokes functions without waiting for human reaction.	System	System	System	System Human
4	Fully autonomous	System invokes functions without informing the human, except in case of emergency.	System	System	System	System

Lloyd´s Register	
Level of autonomy	**Description**
0 / *AL 0	1) No cyber access – no assessment – no descriptive note – included for information only. 2) Manual: No autonomous function. All action and decision-making performed manually (N.B. systems may have level of autonomy, with Human in/ on the loop.), i.e. human controls all actions.
1 / AL 1	1) Manual cyber access – no assessment – no descriptive note – included for information only. 2) On-board Decision Support: All actions taken by human Operator, but decision support tool can present options or otherwise influence the actions chosen. Data is provided by the systems on board.
2 / AL 2	1) Cyber access for autonomous/remote monitoring. 2) On & Off-board Decision Support: All actions taken by human Operator, but decision support tool can present options or otherwise influence the actions chosen. Data may be provided by systems on or off-board.
3 / AL 3	1) Cyber access for autonomous/remote monitoring and control (on board permission is required, on board override is possible). 2) `Active´ Human in the loop: Decisions and actions are performed with human supervision. Data may be provided by the system on or off-board.
4 / AL 4	1) Cyber access for autonomous/remote monitoring and control (on board permission is not required, on board override is possible). 2) Human on the loop. Operator/Supervisory: Decisions and actions are performed autonomously with human supervision. High impact decisions are implemented in a way to give human Operators the opportunity to intercede and over-ride.
5 / AL 5	1) Cyber access for autonomous/remote monitoring and control (on board permission is not required, on board override is not possible). 2) Fully autonomous: Rarely supervised operation where decisions are entirely made and actioned by the system.
AL 6	2) Fully autonomous: Unsupervised operation where decisions are entirely made and actioned by the system. *AL – Autonomy level (stands for second set of levels of autonomy and their definitions)
Det Norske Veritas Germanischer Lloyd & China Classification Society	
Degrees of autonomy	Description
1	Ship with automated processes and decision support.
2	Remotely controlled ship with seafarers on board.
3	Remotely controlled ship without seafarers on board.
4	Fully autonomous ship.

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Classification societies provide technical standards regarding construction and operation of ships and offshore structures. The required standards will apply to autonomous and remotely controlled ships. Also, compliance with the standards required by certain classification society is accomplished via regular inspections or additional surveys. As defined by the Classification Society, these types of ships need to comply with the same or higher standards than conventional ships.

Figure 4 shows progress regarding autonomous ships, which is provided by certain classification societies. Since, these guidelines represent the manifest of each classification society regarding autonomous ships, for the purpose of this paper contents and definitions of autonomy levels are extracted from each guideline.

Table 3 shows each level of autonomy described individually for a comprehensive overview. DNV GL and CCS have the same autonomy levels and definitions, which are replicated from IMO´s degrees of autonomy. In contrast, BV and LR have a different organization of autonomy levels and related definitions. BV´s levels of autonomy define the difference between the role of the human and the role of the system. The role of the human or the system is shared on four functions, which are based on a four-stage model of human information processing. These functions are (Guidelines for Autonomous Shipping, 2017):

Table 4.
Contents from different guidelines for autonomous ships.
(Source: Made by the author, using data of Guidelines for Autonomous Shipping (2017), LR Code for Unmanned Marine Systems (2017), Autonomous and remotely operated ships (2018), Guidelines for autonomous cargo ships (2018).

Bureau Veritas - *Guidelines for Autonomous Shipping*			**Lloyd´s Register - *LR Code for Unmanned Marine Systems***
Section 1-4			**Chapters 1-9; Annexes A, B**
General • General • Safety and • security conditions • Regulations *Risk and Technology Assessment* • General • Risk assessment • Technology assessment	*Guidelines for Functionality of Autonomous Systems* • General • Navigation system • Communication network and system • Machinery system • Cargo management system • Passenger management system • Shore control center	*Guidelines for Reliability of Autonomous Systems* • General • Navigation system • Communication network and system • Machinery system • Cargo management system • Passenger management system • Shore control center	Chapters • General • Structure • Stability • Control system • Electrical systems • Navigation systems • Propulsion and maneuvering • Fire • Auxiliary systems Annex A – Concept of operations Annex B – Verification methods
DNV GL - *Autonomous and remotely operated ships*		**CCS – *Guidelines for autonomous cargo ships***	
Sections 1-7	**Appendixes A-E**	**Chapters 1-14**	
• General • Main principles • Qualification and approval process • Navigations functions • Vessel engineering functions • Remote control centers • Communication functions	•List of potential minimum risk conditions (A) • List of potential autoremote functions (B) • Navigation systems – applicability of conventional carriage requirements for autonomous vessels (C) • Navigations systems – additional systems for autoremote vessels (D) • Simulator based testing (E)	• General • Situation awareness • Navigation control • Machinery installations • Mooring and anchoring • Electrical installations • Communication and signal equipment • Hull construction and safety • Fire-fighting • Environmental protection • Ship security • Remote operation center • Cyber security • Survey and certification	

- Information acquisition.
- Information analysis.
- Decision and action selection.
- Action implementation.

LR´s levels of autonomy are shown as a duplicate to highlight their progress on this matter (Design Code for Unmanned Marine Systems, 2017). Differences that exist among levels of autonomy provided by Classification Societies are presented through comparison in Table 4. These differences are shown through:

- Numbers of levels of autonomy
- Definitions of autonomy levels
- Used terminology.

All autonomy level definitions do not refer to the engine room, which is an essential part of every ship. Also, some definitions (Ramboll) in their nature refer only to the bridge, i.e. to navigation. When comparing all definitions of autonomy levels, autonomy is most commonly referred onto the whole ship or a single system.

Table 4 shows the content of the guidelines provided by Classification Societies. This indicates how the provided guidelines, through technical standards, anticipate that numerous and miscellaneous systems will be fitted on such ships. The systems fitted on autonomous or remotely controlled ships may not mutually be at the same autonomy level, or with regard to the ship in general.

Also, all the contents include a variety of systems which are usually fitted to a conventional ship. As the applicability of autonomous and remotely controlled ships is brought closer to the merchant (cargo) ships, it is unlikely to expect that they may be defined and referred to as a single system. So, it is safe to presume that additional distributions or definitions of autonomy levels among ships and fitted systems, following the achieved progress will be needed. A similar conclusion is drawn during the MSC 99th session, where it is noted that marine ships are comprised of many systems and that autonomy among these systems can vary.

Apart from this, in each content a segment regarding engine room is provided. In the cross-section of this segment, significant deviations are noted. Classification Societies state that each segment from Table 3 should at least match the same level of safety and performance as the same system on a conventional ship. Moreover, according to the provided technical standards, these ships when compared to conventional ships should ensure an equivalent or higher level of safety. Guidelines provided by BV and LR give mostly generic information on this segment. For this reason, a further comparison is conducted between the guidelines provided by DNV GL and CCS.

Regarding engine room, DNV GL in its guidelines differentiates Automatic Operation (AO) and Automatic Support (AS). Automatic Operation is defined as the operation of the vessel´s functions by automation systems, which do not need crew intervention. Automatic Support is defined as the operation of the vessel´s functions by automation systems that operate in combination with the crew.

If engine room machinery is under AO, then manual operations are replaced by automation systems. In that case, remote supervision and emergency control should be arranged in the Remote Control Centre (RCC). For resolving unexpected and abnormal events automation functions should be redundant or augmented by independent automatic safety systems. For example, a power management system on a conventional vessel is in general not provided with redundant control (Autonomous and remotely operated ships, 2018).

If engine room machinery is under AS, then manual operation on board will be performed by the remote engineering watch in RCC. For engineering watch to manage properly, functions that provide decision support should be properly arranged. Propulsion and steering system, along with associated auxiliary systems, can be automatically operated or supported.

In the case when propulsion or steering function is under AS, then:

- Propulsion and steering machinery is under engineering watch control and all actions are manually conducted.
- In the case of poor decision making, a warning should be issued by the decision support system.
- The decision support system should be integrated with other systems.

In the case when propulsion or steering function is under AO, then:

- Propulsion and steering machinery is completely controlled by automation systems as well as supporting auxiliary systems.
- Automation systems should be capable of issuing a notice in due time, before performing a certain order. Propulsion and steering system should be arranged so that manual control and intervention can be performed from the RCC. Restoration of propulsion and steering functions should be arranged in a way that now manual actions are needed.
- If unexpected failures and events are not eliminated by automatic control functions, then alerting, diagnostics, monitoring, and controlling functions should provide adequate data and control for the responsible personnel in RCC to manage the same.
- The engineering watch in RCC should be provided with sufficient monitoring, alerting, diagnostic functions and controls to intervene in case of unexpected events and failures which are not safely handled by the automatic control functions.

In its guidelines, CCS requires additional provisions regarding the engine room. It is stated that, unless provided otherwise, autonomous ships must comply with Chapter 4 of the Rules for Intelligent Ships (Guidelines for Autonomous Cargo

Ships, 2018). According to these rules, autonomous ships are provided with intelligent machinery system, which carries out condition monitoring and fitness management of:

- Main propulsion machinery
- Auxiliary machinery installations
- Boilers and machinery piping systems.

An intelligent machinery system should perform automatic recording of diverse information from all systems in the engine room. Some of this information is navigation instructions, respective action responses from the engine room, operational records specified by regulations, e.g. fuel change-over and maintenance records.

Additionally, intelligent machinery system needs to provide:

- Automatic reporting
- Automatic output of various records and reports
- Feedbacks to RCC.

Although DNV GL and CCS provide detailed information concerning the engine room, in spite of the differences all the presented guidelines provide sufficient basis in a form of technical standards for the development of autonomous ship and remotely controlled ships. From engine room aspect, when relating autonomous or remotely controlled ship concept to the currently deployed merchant or commercial ships, e.g. passenger or cargo ships, some difficulties arise. Such difficulties are mainly based on the complexity of the engine room and the need for personnel to perform maintenance during exploitation.

5. CONCLUSION

Even though human action is stated as the most common cause of accidents on board, it is an indispensable element needed for the exploitation of ships today. Due to their high level of development and thermal efficiency achieved, most commonly used propulsion systems in modern shipping are two-stroke diesel engines, steam and gas turbines or combination marine propulsion systems. These propulsion systems are comprised of heavy-duty machinery which for their operation use different types of fuel oil, lubricants, coolant medium with aggressive additives, etc. That is why engine room on conventional ships is comprised of numerous and complex systems, which require adequate personnel on board for constant monitoring and maintenance. As progress approaches closer to the complete autonomy, the number of crew on board will appropriately be reduced and labor organization on board will change. Therefore, the personnel involved in navigation and engineering functions on those types of ships should undergo specific training and education.

All these reasons emphasize that autonomous and remotely controlled ships cannot be observed exclusively through navigation or bridge autonomy. The autonomy levels mentioned in this paper may be sufficient for the current extent autonomy progress in shipping, i.e. smaller vessels listed in the introduction. Their main purpose is testing and ultimately proofing applicability of autonomy across entire shipping.

Therefore, currently provided guidelines for autonomous and remotely controlled ships, levels of autonomy and achieved progress in this field do not prove to be sufficient for creating a tenable relation of autonomy or remote control to the conventional merchant ships deployed in modern shipping.

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CONTRIBUTION

Pjesme / Poems
Guidelines

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ART

ŠÏDRO

Ante Božanić

Pepe Kalofot

SIDRO / THE ANCHOR

trans. by Mirna Čudić Žgela

Mājna jìdro, śūrga ŝìdro
ako užȏś iśkìdonu jìdro
ne deperōj śtōru ŝìdro
śovra pensīr śvāne dōn

kurē ūre
kurē Inèvi
śetemōne
pūśu jùga
tramuntōne
garbīni śu arvāli
dvī onkòre
daprōva śurgāli

bròdi śu na korpomōrta
u njīh pjūśko, trīśko bòta
pūśe lebìć o burīn
ōśtrośiròk i garbīn

a da ŝìdro ne podère
bùta dùplu prī nevēre
śūrga śōldi ankorōj
da ne dūjde brūd na krōj
teśki pīź će iźdurāt
śvićōr mòre mīrno śpāt

u marīnu
armiźōn na kūnce
u komīśku vālu
ne bìś docèkol
na ìśtoku śūnce.

Lower the sail, put down the anchor
If you use a torn sail
do not use an old anchor
a safe anchor – peaceful sleep
with no care or fear
till the break of dawn

the hours pass
the days go by
the weeks
with sciroccos
north winds
southern gales
raging and howling
two anchors securing the bow

the boats are moored
splashed and whipped by the waves
easterly and northerly breezes whistling
southerly winds and gales roaring

and to stop the anchor dragging
double it before the storm
put a strong anchoring
till the boat comes ashore
the heavy weight will endure
the captain can sleep undisturbed

in the marina
moored and anchored by threads
in Komiža Bay
you would not live
to see the sunrise.

RJEČNIK

šurgat	spustiti, baciti (u more)
užat	rabiti, upotrebljavati
deperat	rabiti, upotrebljavati
pensir	misao, briga
kurit	ići brzo, trčati, protjecati (vrijeme)
setemona	tjedan
tarmuntona	tramontana, sjeverni vjetar, sjeverac
garbin	jugozapadni olujni vjetar
arvat	doći, stići
onkora	sidro
daprova	po pramcu
korpomorto (bove)	komad kamena ili betona za vezanje plutače
triskat	udarati, tući
lebić	olujni jugozapadnjak
oštar, oštrošírok	južni vjetar
butat	staviti
nevera	nevrijeme, oluja
ankoroj	sidrište
piz	uteg, teret
svićor	zapovjednik ribarske družine
kunce	konop tanak poput konca

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ART

ŚOMÀ ŚOMCÃTA

Ante Božanić

Pepe Kalofot

ALONE, ALONE, ALL ALONE

trans. by Mirna Čudić Žgela

Ćûtin iź dubinē tīla
kìda śon bīla
śa tòbon u kokpìto
kakò onu lìto
kal śmo śe kortejāli
jòś nīśmò ni źnāli
dì ćemo burdižāt
i kòko ćemo iźdurāt

nemūj mìslit da ne grēn
i jō śe vajōn oparćāt
tèbi ròbu śuprašāt
švetemu Mikùli śe pomolìt
Bògu źafolìt
da vìtar bùde imfavūr
da nī potrìba opūtìt motūr

na partēncu nećù moć dūć
nīmo kù na dìcu avertìt
u škùlu vajō bìt

ma jō
jō śon bīla na partēncu
jer ćûtin švāki pòkret tvojē rukē
na ròtu i bòtu, na temūn i škòtu
je plōce śantīnu dok nateźeś lantīnu
pīto Dīno je śe jovīl tāta
a Marìja glèdo brāta, prìko òka
jō źnōn, paśāle śu nevēre
glèdon na alerūj švēre
tamān śe poklopìle
dèvet mānje kvārat
i źnōn da mìsliś na nōś
ali nekà źnōś
da i jō regatōn

I feel, I feel
from the depth of my being, from the bottom of my body and soul
as if we were
once again in the cockpit together
as in that long-gone summer
when we were young and in love
and did not know
where the winds would take us, along which course our boat would sail
or how long we would endure

do not think that I am not going
I still have to get ready:
to iron your clothes
to say a prayer to St Nicholas
to give praise to the Lord
to pray for a favourable wind
so that the engine need not be started

I cannot come to see you off
someone has to stay to look after the children
to take them to school

Nevertheless, I,
I did come to see you off
for I can still feel every move of your hand
on the helm, on the rudder, on the sail making sure that the wave is not splashing
washing over the bottom while you are tightenin up the sail rope

Dino asks if I have heard from Daddy
and Mary gives her brother an inquisitive look askance
I know, the storms are over
I look at the hands of the clock

tmūrno źimskò nūć
lancūn śtùden
kāl ćeś dūć
blaźìnja proźnà
u pośtèju mūk
jō śe vartīn
śāl na līvi
śāl na dèsni būk
i cùjen ol vìtra hūk

śveti mūj Mikùla
pomoźì dūć krāju
duśā, tīlo pāti
kroź źivòt me cèko
još pùno regātih.

Za sve žene ribara i pomoraca
Od savudrije do rta Oštra
Pēpe kalafōt iź Komìže!

they have just come together
a quarter to nine
and I know you are thinking of us
but you should know, you have to know
that I too am sailing with you

a dark, gloomy winter night,
the sheets ice-cold,
when will you return,
the pillowcase empty, silent the bed
I toss and turn
over
and over
and I can hear
the wind howling, raging, roaring

St Nicholas, I implore you
help me make it through all this
my soul and my body ache
in this life there are still
many regattas ahead of us

Dedicated to all the wives of seamen and fishermen
from the Bay of Savudria (in Istria) to Cape Oštro

RJEČNIK

kopito	prostor u jedrilici za boravak i rad posade
kortejat se	udvarati se, zabavljati se s djevojkom/mladićem
burdižat	ploviti
izdurat	izdržati, istrajati
oparćat	pripremiti, spraviti
šuprašat	izglačati
infavur	(tal. in favore) povoljan
avertit	paziti, čuvati, biti na oprezu
partenca	odlazak na putovanje ili plovidbu
rota	smjer, kurs
bota	val
temun	kormilo
škota	konop za natezanje jedra
plokat	prelijevati, zapljuskivati
santina	dno broda, prostor između rebara
lantina	donja prečka jedra
aleruj	sat
švere	kazaljke
kvarat	četvrt, četvrtina
regatat	ploviti u regati
lancun	plahta
blazinja	jastučnica

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About ToMS: Ethics, Conflict of Interest, License and Guides for Authors

The Journal is published in English as an open access journal, and as a classic paper journal (limited edition).

ToMS aims at presenting the best maritime research primarily, but not exclusively, from Southeast Europe, particularly the Mediterranean area. Papers will be double-blind reviewed by 3 reviewers. With the intention of providing an international perspective at least one of the reviewers will be from abroad. ToMS also promotes scientific collaboration with students and has a section entitled Students' ToMS. These articles also undergo strict peer reviews. Furthermore, the Journal publishes short reviews on significant papers, books and workshops in the fields of maritime science.

Our interest lies in general fields of maritime science (transport, engineering, maritime law, maritime economy) and the psychosocial and legal aspects of long-term work aboard.

1. PUBLICATION ETHICS

Ethical Policies of ToMS

Plagiarism is arguably the most complicated ethical issue. Our policies define plagiarism as "taking material from another's work and submitting it as one's own." ToMS *holds authors — not the Publisher or its editors and reviewers — responsible* for ensuring that all the ideas and findings included in a manuscript are attributed to the proper source. We also refer to our role as steward of what constitutes ethical conduct. Ethical misconduct is the reason for our commitment to continue to strive to educate all the parties in the publishing process how to handle this matter. As a member of Crossref, ToMS has a powerful weapon – iThenticate system, which is not perfect.

"Even if there were reliable and sensitive plagiarism detection software, many issues would remain to be addressed.

For example, how much copying is legitimate? Clearly, the reuse of large amounts of others' text constitutes plagiarism. But what should one think about copying short passages from the author's own earlier work, such as commonly occurs in the Methods section? In the Nature article it is suggested that some journals set a quantitative limit whereby the amount of text that can be reused is limited to about 30 percent. This may be utilitarian, but it seems curious and arbitrary that 25 percent of copied text might be deemed acceptable whereas 30 percent might not. Indeed, two authors who copied the same number of words could find themselves on opposite sides of that border if one author simply was more verbose and thus diluted their plagiarized content below the threshold! No, this is not a simple issue at all." [cited from: http://newsletter.aspb.org/ethics.cfm]

Expectations for Publishing in ToMS

Faculty of Maritime Studies expects authors submitting to and publishing in its journals to adhere to ethical standards to ensure that the work they submit to or publish in the journal is free of scientific misconduct. Authors must:

- Take credit only for work that they have produced.
- Properly cite the work of others as well as their own related work.
- Submit only original work to the journal.
- Determine whether the disclosure of content requires the prior consent of other parties and, if so, obtain that consent prior to submission.
- Maintain access to original research results; primary data should remain in the laboratory and should be preserved for a minimum of five years or for as long as there may be reasonable need to refer to them. All authors of articles submitted for publication assume full responsibility, within the limits of their professional competence, for the accuracy of their paper. Instances of possible scientific misconduct related to papers submitted to or published in the ToMS will be addressed by following the procedure outlined below.

2. CONFLICT OF INTEREST

The authors, reviewers and other participant are obligated to clearly state possible conflict of interest. Editor-in-chief, senior editor and/or executive editors board decide on actions based on conflict of interest (COI).

Editors' Duty

Disclosure and Conflicts of Interest: The editor cannot use unpublished materials, disclosed in submitted manuscript for his/her own research, without prior written consent of the author(s).

If author(s) of submitted paper is a member of editorial board or editor-in-chief, the submission, review and decision process is carried by the highest ranking editor who is not the author.

Reviewers' Duty

All reviewers should have no conflict of interest with respect to the research, the authors and/or the funding bodies.

3. MALPRACTICE

Procedure for addressing allegations of scientific misconduct or other ethical violations

Scientific misconduct in publishing includes but is not limited to:

- Data manipulation;
- Data falsification;
- Fraud: fabricating a report of research or suppressing or altering data;
- Duplicate publication;
- Plagiarism and
- Self-plagiarism.

Procedure for handling allegations of misconduct

- All allegations of scientific misconduct or ethical violation will be referred to the editor for research integrity or to the editor-in-chief. All allegations should be made in writing.
- Editor for research integrity will report the case in the meeting of the Editorial board and recommend the actions in 30 days.
- Except redraw of the paper, punishment could be inclusion in the black list of the journal and prohibition of further publishing in ToMS.

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Submission of an article implies that the work described has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis or as an electronic preprint), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere including electronically in the same form, in English or in any other language, without the written consent of the copyright-holder.

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Multiple, Redundant, or Concurrent Publications: Authors should not concurrently submit the same manuscript for publishing to other journals, or conference proceedings. It is also expected that the author(s) will not publish redundant manuscripts, or manuscripts describing the sameresearch in several publishing venues, after the initial manuscript has been accepted for publication.

Acknowledgement of Sources: Author(s) should acknowledge all sources of data used in the research and cite publications that have influenced their research.

Authorship of the Paper: Authorship should be limited only to those who have made a significant contribution to conceiving, designing, executing and/or interpreting the submitted study. All those who have significantly contributed to the study should be listed as co-authors. The corresponding author should also ensure that all the authors and co-authors have seen and approved the final submitted version of the manuscript and their inclusion as co-authors.

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Conflict of Interest: All reviewers should have no conflict of interest with respect to the research, the authors and/or the funding bodies.

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Publication Decisions: Based on the editorial board's review, the editor can accept or reject the manuscript or can send it for modifications.

Review of Manuscripts: The editor ensures that each manuscript is initially evaluated by the editor, who may make use of appropriate means, to examine the originality of the contents of the manuscript. After the manuscript passes this test, it is forwarded to two reviewers for double-blind peer review, and each of whom will make a recommendation to publish the manuscript in its present form or to modify or to reject it. The review period will be no more than30 days.

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6. GUIDELINES FOR AUTHORS

The Journal is published in English as an open access journal, and as a classic paper journal (limited edition).

ToMS aims at presenting the best maritime research primarily, but not exclusively, from Southeast Europe, particularly the Mediterranean area. Papers will be double-blind reviewed by 3 reviewers. With the intention of providing an international perspective at least one of the reviewers will be from abroad. ToMS also promotes scientific collaboration with students and has a section entitled Students'ToMS. These articles also undergo strict peer reviews. Furthermore, the Journal publishes short reviews on significant papers, books and workshops in the fields of maritime science.

Our interest lies in general fields of maritime science (transport, engineering, maritime law, maritime economy) and the psychosocial and legal aspects of long-term work aboard.

6.1. Before you Begin

6.1.1. Ethics in publishing

For information on Ethics in publishing and Ethical guidelines for journal publication see Publication Ethics

6.1.2. Conflict of interest

All authors are requested to disclose any actual or potential conflict of interest including any financial, personal or other relationships with other people or organizations within three years of beginning the submitted work that could inappropriately influence, or be perceived to influence, their work.

6.1.3. Submission declaration

Submission of an article implies that the work described has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis or as an electronic preprint), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere including electronically in the same form, in English or in any other language, without the written consent of the copyright-holder.

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- a. the reason the name should be added or removed, or the author names rearranged and
- b. written confirmation (e-mail, fax, letter) from all authors that they agree with the addition, removal or rearrangement. In the case of addition or removal of authors, this includes confirmation from the author being added or removed. Requests that are not sent by the corresponding author will be forwarded to the Journal Editors and to the corresponding author, who must follow the procedure as described above.
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Note that:

- - publication of the accepted manuscript in an online issue is suspended until authorship has been agreed.
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6.2. Guidelines for Authors: Manuscript Preparation and Submission

6.2.1. Organization of the manuscript

First (title) page

The first page should carry:

- a. the paper title;
- b. full names (first name, middle – name initials, if applicable), and last names of all authors;
- c. names of the department(s) and institution(s) to which the work should be attributed. If authors belong to several different institutions, superscript digits should be used to relate the authors' names to respective institutions. Identical number(s) in superscripts should follow the authors names and precede the institution names;
- d. the name, mailing address and e-mail of the corresponding authors;
- e. source(s) of research support in the form of financial support, grants, equipment or all of these.

Last page

The last page should carry:

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- a. ethical approval, if required;
- b. authors' declarations on their contributions to the work described in the manuscript, their potential competing interests, and any other disclosures. Authors should disclose any commercial affiliations as well as consultancies, stock or equity interests, which could be considered a conflict of interest. The details of such disclosures will be kept confidential but ToMS urges the authors to make general statements in the Acknowledgement section of the manuscript.
- c. a list of abbreviations used in the paper (if necessary);

Other pages

Each manuscript should follow this sequence:

- • title page;
- • abstract;
- • text (Introduction, Methods, Results, Conclusions/ Discussion);
- • acknowledgments;
- • references;
- • tables (each table complete with title and footnotes on a separate page);
- • figures and figure legends, and the last page.

6.2.2. Text organization and style

6.2.2.1. Abstract

The second page should contain the Abstract. ToMS requires that the authors prepare a structured abstract of not more than 250 words. The abstract should include (at least) four sections: Aims, Methods, Results, and Conclusion, not necessarily separated.

Aim. State explicitly and specifically the purpose of the study.

Methods. Concisely and systematically list the basic procedures, selection of study participants or laboratory/ experimental/simulation setup, methods of observation (if applicable) and analysis.

Results. List your primary results without any introduction. Only essential statistical significances should be added in brackets. Draw no conclusions as yet: they belong in to the next section.

Conclusion. List your conclusions in a short, clear and simple manner. State only those conclusions that stem directly from the results shown in the paper. Rather than summarizing the data, conclude from them.

6.2.2.2. Main text

Do not use any styles or automatic formatting. All superscripts or subscripts, symbols and math relations should be written in MathType or Equation editor.

Introduction

The author should briefly introduce the problem, particularly emphasizing the level of knowledge about the problem at the beginning of the investigation. Continue logically, and end with a short description of the aim of the study, the hypothesis and specific protocol objectives. Finish the section stating in one sentence the main result of the study.

Results

Key rules for writing the Results section are:

- a. the text should be understandable without referring to the respective tables and figures, and vice versa;
- b. however, the text should not simply repeat the data contained in the tables and figures; and
- c. the text and data in tables and figures should be related to the statements in the text by means of reference marks.
-

Thus, it is best to describe the main findings in the text, and refer the reader to the tables and figures, implying that details are shown there. The formulations such as "It is shown in Table 1 that the outcome of Group A was better than that of Group B" should be replaced by "The outcome of Group A was better than that of Group B (Table 1)."

The need for brevity should not clash with the requirement that all results should be clearly presented.

Discussion/Conclusions

The discussion section should include interpretation of study findings in the context of other studies reported in the literature. This section has three main functions:

- a. assessment of the results for their validity with respect to the hypothesis, relevance of methods, and significance of differences observed;
- b. comparison with the other findings presented in the relevant literature; and
- c. assessment of the outcome's significance for further research.
-

Do not recapitulate your results, discuss them!

6.2.2.3. Tables

Information on significance and other statistical data should preferably be given in the tables and figures. Tables should not contain only statistical test results. Statistical significances should be shown along with the data in the text, as well as in tables and figures.

Tables should bear Arabic numerals. Each table should be put on a separate page. Each table should be self-explanatory, with an adequate title (clearly suggesting the contents), and logical presentation of data. The title should preferably include the main results shown in the table. Use tables in order to present the exact values of the data that cannot be summarized in a few sentences in the text.

Avoid repetitive words in the columns: these should be abbreviated, and their explanations given in the footnotes. Present data either in a table or a figure.

Each column heading for numerical data given should include the unit of measurement applied to all the data under the heading. Choose suitable SI units.

Place explanatory matter in footnotes, not in the heading.

Explain in footnotes all nonstandard abbreviations that are used in each table.

6.2.2.4. Figures

Figures should be numbered in sequence with Arabic numerals. Legends to figures should be listed on a separate page, in consecutive order. Minimum resolution for all types of graphics is 300 dpi and 600 dpi is recommended. The legend of a figure should contain the following information:

- a. the word "Figure", followed by its respective number;
- b. figure title containing major finding (e.g. Manuscripts which follow Guidelines for Authors had higher acceptance rate, and not Relationship with manuscripts style and their acceptance rate).
-

Use simple symbols, like closed and open circles, triangles and squares. Different types of connecting lines can be used. The meanings of symbols and lines should be defined in the legend.

Each axis should be labeled with a description of the variable it represents.

Only the first letter of the first word should be capitalized. The labeling should be parallel with the respective axis. All units should be expressed in SI units and parenthesized. Make liberal use of scale markings.

Graphs, charts, titles, and legends in accepted manuscripts will be edited according to ToMS style and standards prior to publication.

Preferred format for graphs or charts is xls. Graphs and charts saved as image (raster) files such as JPG, TIF, or GIF and imported or copied/pasted into Word or Power Point are not acceptable.

The resolution for photographic images should be at least 300 dpi, and minimum image width should be 6 cm. Please submit files in RGB format. For published manuscripts, image files will be posted online in their original RGB format, maintaining the full color of your original files. Note that we will still need to convert all RGB files to CMYK for printing on paper and color shifts may occur in conversion. You will not receive a CMYK proof. You can view an approximation of print results by converting to CMYK in Adobe® Photoshop® or Adobe® Illustrator®.

6.2.2.5. Authorship statement

All contributing authors must fill out and sign these statements and submit them to the Editorial Office. Accepted manuscripts will not be published until signed statements from all authors have been received.

6.2.2.6. Acknowledgments

Technical help, critical reviews of the manuscript and financial or other sponsorship may be acknowledged. Do not acknowledge paid services, e.g. professional translations into English.

6.2.2.7. References

References cited in the manuscript are listed in a separate section immediately following the text. The authors should verify all references. Usage of DOIs is mandatory.

Examples of citation in text:

It is well known fact (Strang and Nquyen, 1997; Antoniou, 2006) that FT is not an appropriate tool for analyzing nonstationary signals since it loses information about time domain.

First group of authors (Vetterli and Gall, 1989) proposed Multiresolution Signal Analysis (MRA) technique or pyramidal algorithm. Second group (Crochiere et al., 1975; Crochiere and Sambur, 1977) proposed subband coding algorithm. Legal acts are cited as in example: The Constitution of the Republic of Croatia (Constitution of the Republic of Croatia, 2010) is the main legal source for this subject matter, as well as any other subject matter relating to the Croatian legal system. References from the Web are cited in the text as (Author(s) last name, year of origin if known (year of accessed in other cases). If the author is unknown, such as in case of company web page, instead of author's name, title of the web page is used.

Examples for reference section:

Journals

Petrinović, R., Wolff, V. S., Mandić, N. and Plančić, B., (2013), International Convention on the Removal of Wrecks, 2007. – a New Contribution to the Safety of Navigation and Marine Environment Protection, Transaction on Maritime Science, 2(1), pp. 49-55., https://doi.org/10.7225/toms.v02.n01.007

Pennec, E. and Mallat, S., (2005), Sparse Geometric Image Representations with Bandelets, IEEE Transactions on Image Processing, 14(4), pp. 423 – 438., https://doi.org/10.1109/TIP.2005.843753

Web links

Donoho, D., Duncan, M. R., Huo, X. and Levi, O., (1999), Wavelab, available at: http://www.stat.stanford.edu /_wavelab/, [accessed 12 August 2011.].

Unknown, Wavelab, available at: http://www.stat.stanford.edu /_wavelab/, [accessed 12 August 2011.].

ToMS home page, available at: http://www.toms.com.hr, [accessed 12 July 2012.].

https://doi.org/10.24355/dbbs.084-202001071320-0

Books

Mallat, S., (2009), A Wavelet Tour of Signal Processing, 3rd Edition, New York: Academic Press.

Chapter in book

Hymes, D. H., (1972), On Communicative Competence, in: Pride, J. B. and Holmes, J. (eds), Sociolinguistics, Selected Readings, pp. 269-293. (Part 1 if exists), Harmondsworth: Penguin.

Šoda, J., Beroš, S. M., Kuzmanić, I. and Vujović, I., (2013), Discontinuity Detection in the Vibration Signal of Turning Machines, in: Öchnser A. and Altenbach, H. (eds), Experimental and Numerical Investigation of Advanced Materials and Structures, Advanced Structured Materials (serial name if applicable), 41 (volume number if applicable), pp 27-54. (part if applicable), Heidelberg: Springer., https://doi.org/10.1007/978-3-319-00506-5_3

Conference proceedings

Łutowicz, M. and Lus , T., (2013), Effect of Loss of Cylinder Pressure Indicating Channel Patency on Parameters Values Obtained from Indicating Graph, Proc. 5th International Maritime Science Conference, Solin, Croatia, April 22 – 23, pp. 382-389., available at: http://www.pfst.hr/imsc/archive/2013/IMSC2013_proceedings.pdf

Kingsbury, N.G. and Magarey, J.F.A., (1997), Wavelet Transforms in Image Processing. Proc. First European Conference on Signal Analysis and Prediction, Prague, Czech Republic, June 24 – 27, Birkhauser, pp. 23 – 24., available at: http://www.sigproc.eng.cam.ac.uk/~ngk/publications/ngk97b.zip, [accessed 12 August 2011.].

Regulations, standards or legal acts:

Constitution of the Republic of Croatia, (2010), Narodne novine, 2010(76), pp. (if known).

6.2.2.8. Supplementary materials

Supplementary materials are optional. Authors can submit different types of materials which will be available on-line.

6.2.2.9. Language

Authors may use standard British or American spelling, but they must be consistent. The Editors retain the customary right to style and, if necessary, shorten texts accepted for publication.

This does not mean that we prefer short articles – actually, we do not limit their size - but rather a resection of the obviously redundant material.

The past tense is recommended in the Results Section.

Avoid using Latin terms; if necessary, they should be added in parentheses after the English terms. Real names rather than "levels" or "values" should refer to parameters with concrete units (e.g. concentration).

6.2.2.10. Abbreviations

Only standard abbreviations and symbols may be used without definition and may be used in the title or the page-heading title.

Non-standard abbreviations should not be used in the title or page-heading title. They must be explained in the text in the following way: the term should be written in full when it appears in the text for the first time, followed by the abbreviation in parentheses; from then on, only abbreviation is used in the text. This applies separately to the Abstract and the rest of the text.

6.2.3. Submission of manuscripts

Paper submission via ToMS web page Open Journal System.
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https://doi.org/10.24355/dbbs.084-202001071320-0